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# A STATISTICAL ANALYSIS OF THE DOMESTIC DEMAND FOR LEMONS, 1921-1941

by

G. M. Kuznets and Lawrence R. Klein

June, 1943

Giannini Foundation of Agricultural Economics
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# A STATISTICAL ANALYSIS OF THE DOMESTIC DEMAND FOR LEMONS, 1921-1941

G. M. Kuznets [1] and Lawrence R. Klein [2]

## Introduction

This report presents some of the results of a study of the lemon industry now in progress at the Giannini Foundation of Agricultural Economics of the University of California. Specifically, this paper describes a statistical analysis of the demand relations facing handlers [3] of California lemons.

The period under review is the twenty-year period 1921 to 1941. The geographic market for the purposes of this study is the continental United States. During the last half of the period, that is, since 1932, practically all of the lemons marketed in the United States were produced in California. This, however, is not true of the first part of the period. In some of the earlier years imports constituted a significant fraction of our total lemon supply.

California lemons are marketed in the United States throughout the year. The marketing year is generally taken to be the twelve-month period, November 1 to October 31. Numerous references in the trade literature point to the notion that the demand for lemons marketed during the winter months is affected by the prevalence of colds and influenza, while the demand during the summer months is greatly responsive to weather conditions. It would thus appear that greater homogeneity would be attained by a separate consideration of the demand situation prevailing during the winter and summer months. For this reason separate analyses are

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[1] Instructor in Agricultural Economics, Junior Agricultural Economist in the Experiment Station, and Junior Agricultural Economist on the Giannini Foundation.

[2] Research Assistant on the Giannini Foundation, June to September, 1942.

[3] A "handler" is defined by the California Agricultural Prorate Act as "any person receiving agricultural commodities from the producer for the purpose of marketing the same." Statutes of California, 1933. Chapter 754.

presented in this paper for lemons shipped during the six months November through April (winter lemons) and for those shipped in May through October (summer lemons) of each marketing year.

The time sequence of seasonal average f.o.b. prices and domestic shipments of lemons is portrayed for the months November through April in panel A, and for May through October in panel B of figure 1. [4] It will be observed that both shipment series exhibit a marked upward trend. Accompanying the upward trend in shipments is a price trend which exhibits, at least for winter lemons, an obvious discontinuity roughly near the middle of the twenty-year period. For both winter and summer lemons the price trend is upward for the nine years 1922 through 1930. For the remaining eleven years the trend in the f.o.b. prices of winter lemons is horizontal, while the trend of the prices of summer lemons is declining. The tendency for the differential between f.o.b. prices of winter and summer lemons to diminish is evident. Attention should also be drawn to the marked season-to-season fluctuations in the separate price series. The expected inverse relation between the year-to-year movements of prices and shipments is discernible for both winter and summer lemons, but exceptions to this tendency may be noted.

Such is the course that prices and shipments have taken during the period under consideration. What are the factors that have fashioned this sequence? How much and in what manner have these factors influenced the two time series? These are the questions considered in this paper.

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[4] These series are given in appendix A. The price series consist of the average prices, f.o.b. packing house, of lemons marketed by the California Fruit Growers Exchange.

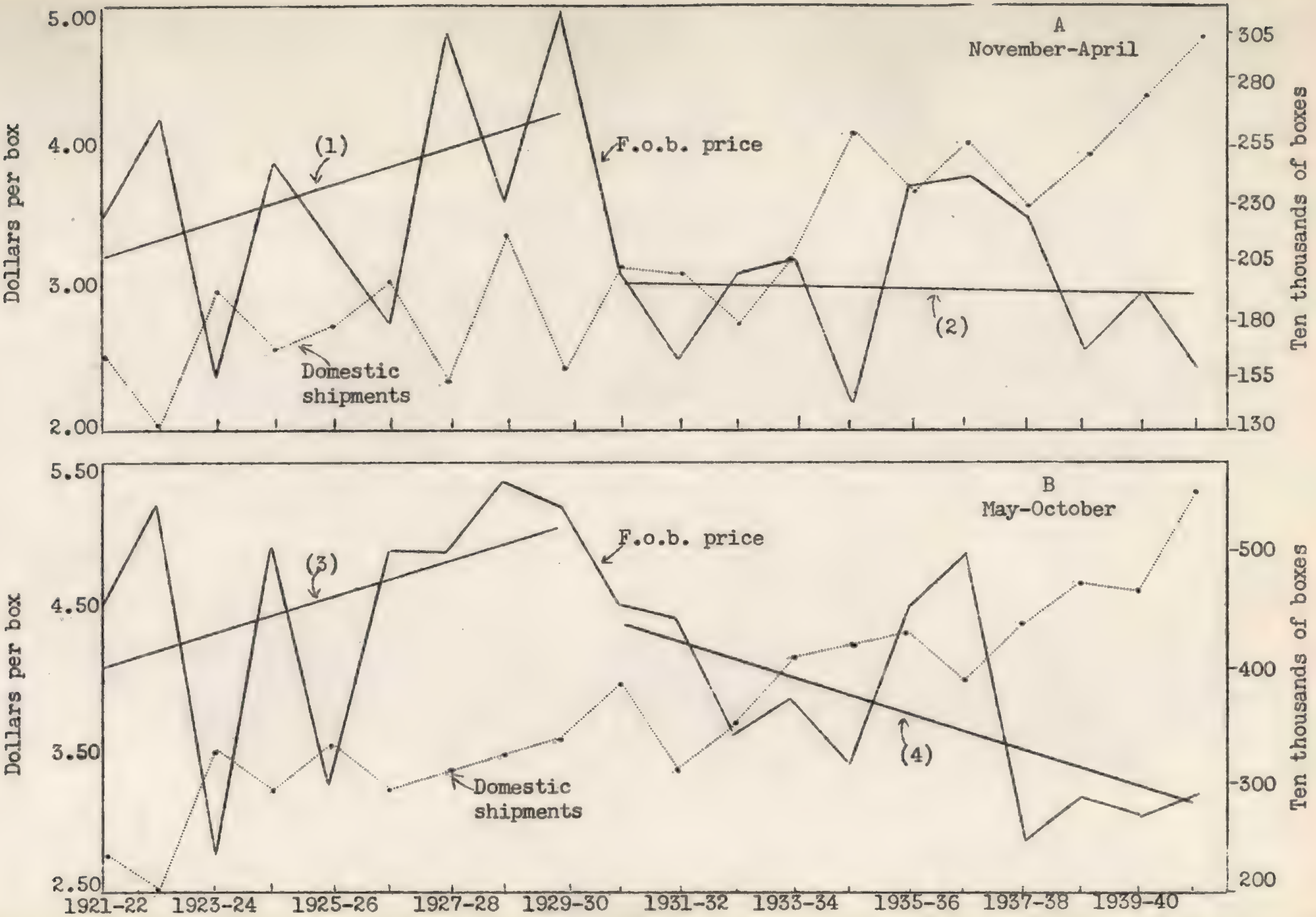
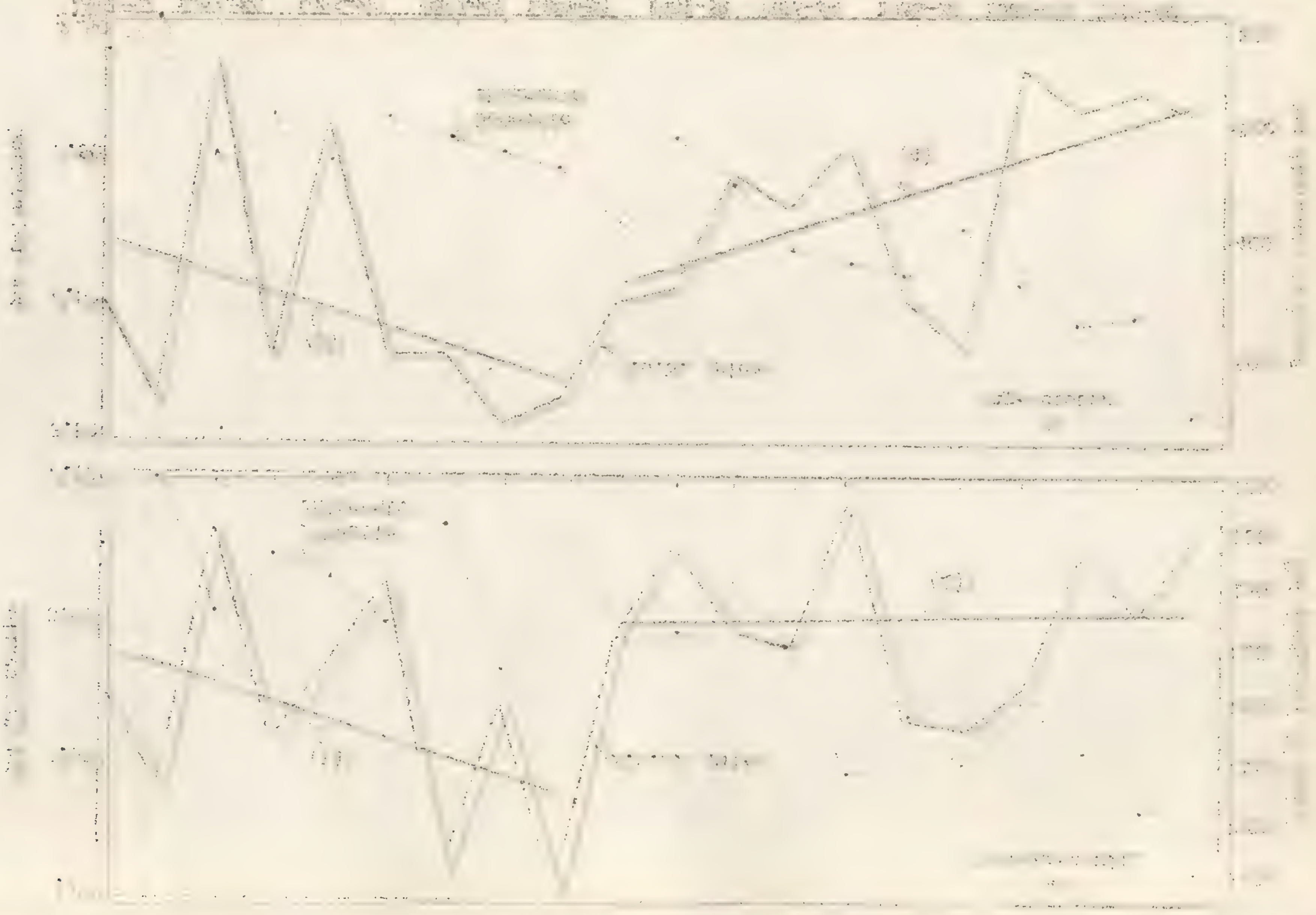


Fig. 1.-- California f.o.b. price and domestic shipments of (A) winter and (B) summer lemons, 1921-22 to 1940-41. The equations of the least squares price trend lines are (1) $p'_W = 3.7022 + 0.1283\ t_1$ (origin at 1925-26), (2) $p''_W = 3.0027 - 0.0066\ t_2$ (origin at 1935-36), (3) $p'_S = 4.5433 + 0.1230\ t_1$ (origin at 1926), (4) $p''_S = 3.7627 - .1255\ t_2$ (origin at 1936). (Data from tables 13, 17, and 18, appendix A.)

[illegible]



## Statistical Considerations

Formally, the observations of price and quantity recorded in the market may be viewed as the simultaneous solutions of the equations,

$$\begin{aligned} f_t\,(p, q; a'_t, a''_t, \ldots, a^m_t) &= 0 \\ g_t\,(p, q; b'_t, b''_t, \ldots, b^n_t) &= 0 \end{aligned} \qquad t = 1, 2, \ldots, N$$

where p is price, q is quantity, $f_t$ is the demand schedule at time t, $g_t$ is the supply schedule, $a^i_t$ and $b^j_t$ are the parameters of the two schedules. It is probably psychologically more defensible and logically more convenient to view the market observations as the simultaneous solutions of the above equations in a stochastic model, after a random component has been added to each; that is, as the solutions of

$$\begin{aligned} f_t\,(p, q; a'_t, a''_t, \ldots, a^m_t, s'_t) &= 0 \\ g_t\,(p, q; b'_t, b''_t, \ldots, b^n_t, s''_t) &= 0 \end{aligned} \qquad t = 1, 2, \ldots, N$$

where $s'_t$ and $s''_t$ are random variables.

If one of the two curves $f_t$ or $g_t$ remained fixed while the other shifted, the price-quantity scatter would trace out the stable curve. This situation, it has been argued, is approximated for some commodities, such as agricultural staples.[5] Clearly, however, this condition is not met by our data. It is reasonable to assume that the supply curve for lemons has not remained fixed, but has shifted in response to varying crop conditions and to changes in other factors. But it cannot be assumed that the demand schedule has remained fixed. The demand for lemons is presumed to be affected by weather conditions during the summer months and by the prevalence of colds and influenza during the winter. These are abruptly changing factors which should induce erratic shifts of the demand curve from one period to another.

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[5] Schultz, H. The theory and measurement of demand. The University of Chicago Press. Chicago, 1938. p. 136.

[illegible]

Formally, the observations of price and quantity recorded in the market may be [illegible]:

$$f_t(p, q; a_t^1, a_t^2, \ldots, a_t^m) = 0 \qquad t = 1, 2, \ldots, N$$
$$g_t(p, q; b_t^1, b_t^2, \ldots, b_t^n) = 0$$

where p is price, q is quantity, $f_t$ is the demand schedule at time t, $g_t$ is the supply schedule, $a_t^i$ and $b_t^j$ are the parameters of the two schedules. It is probably theoretically more defensible and formally more convenient to view the market observations as the simultaneous solutions of the above equations in a stochastic model, after a random component has been added to each; that is, as the solutions of

$$f_t(p, q; a_t^1, a_t^2, \ldots, a_t^m, s_t) = 0 \qquad t = 1, 2, \ldots, N$$
$$g_t(p, q; b_t^1, b_t^2, \ldots, b_t^n, s_t') = 0$$

where $s_t$ and $s_t'$ are random variables.

If one of the two curves $f_t$ or $g_t$ remained fixed while the other shifted, the price-quantity scatter would trace out the stable curve. This situation, it has been argued, is [illegible] condition.[3] Clearly, however, this condition is not met by our data. It is reasonable to assume that the supply curve for lemons has not remained fixed, but has shifted in response to varying crop conditions and to changes in other factors. But it cannot be assumed that the demand schedule has remained fixed. The demand for lemons is presumed to be affected by weather conditions during the summer months and by the prevalence of colds and influenza during the winter. These are abruptly changing factors which should induce erratic shifts of the demand curve from one season to another.

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[3] Schultz, H., The Theory and Measurement of Demand. The University of [illegible]

With both schedules shifting, the parameters of the theoretical demand schedule could still be estimated if (1) the form of the demand curve, (2) the complete set of shift variables, and (3) the distribution functions of the random components were known. Not all of these items of information, however, are equally important for the determination of statistical demand functions. It is argued here that useful demand equations can be secured even if nothing is known concerning the form of the demand function and the distribution functions of the random components.

Let us suppose that we are able to catalogue and measure the important factors which cause the demand to shift, and that these factors are, on the whole, distinct from those that affect supply. Let us then choose some function and some method of fit -- being guided in this primarily by considerations of simplicity and convenience, but taking care not to gainsay whatever information is supplied by economic theory and our acquaintance with the commodity and its markets. Finally, let us suppose that with these shift variables and this function we have secured an excellent fit (the measure of goodness of fit being consistent with our assumptions concerning the random components). The resulting equation is not the market demand schedule of the theoretical economist, but it is something more than just an estimation equation for predicting price and quantity. It is clearly an equation pertaining to the *demand* side of the market. Such equations, it is felt, should give us an insight into the demand relations prevailing in the market.

The foregoing argument constitutes in a sense the rationale of this study. The remainder of this section is devoted to a more detailed consideration of the procedure we have followed.

1. *Shift Variables*.-- Among the shift variables we have employed are indexes measuring the level of temperatures prevailing in the important metropolitan districts of this country, income payments used as a measure of consumer purchasing power, and "time." There is little doubt that the temperature variables measure factors which act on the demand side of the market. The most obvious influence of temperature on supply is through the effect on crop conditions, but the geographical

coverage of the temperature variable excludes this possibility. "Time" should be adequate for "explaining" shifts in demand due to widespread advertising campaigns and gradual changes in consumption habits. Income payments, in so far as they represent consumer purchasing power, are a demand factor; but the role played by this variable is equivocal because this index could be used as a measure of general business conditions and thus be simultaneously (although with a smaller weight) a supply factor. These variables considered as a group, however, are seen to be important on the demand rather than the supply side of the market.

2. Form of Equations.-- In this study, price or quantity was expressed as a linear function of the shift variables or of their logarithms. By this it was implicitly assumed that the shifts of the demand schedule are parallel. At a time t the net relation between price and quantity is $p = aq + d_t$ or $\log p = a' \log q + d'_t$, where $d_t$ and $d'_t$ are the shift parameters of the demand schedule. It is evident that $d_t$ is a weighted average of the values of the shift variables at time t, and that $d'_t$ is a similar average of their logarithms -- the weights in both cases consisting of the coefficients of the shift variables.

The conventional character of this procedure must be emphasized. There is a temptation to attach too much significance to the specific form of the net relations, especially if the fit of the total equation is good. However, other functions describing markedly different net relations might fit the data equally well and possibly better than the functions selected by the investigator. It is chiefly because of the uncertainty concerning the form of the net relations that two different, yet *a priori* equally admissible functions, were fitted. But it is not intended that this choice imply that the true relations lie somewhere between the net relations described by the two functions.

3. Method of Fit.-- If the statistical results of this paper are to be looked upon merely as estimation equations, then the following model may be adopted:

[illegible] "Time" should be [illegible] for "explaining" shifts in demand due to widespread advertising campaigns and gradual changes in consumption habits. Income payments, in so far as they represent consumer purchasing power, are a demand factor; but the role played by this variable is equivocal because this index could be used as a measure of general business conditions and thus be simultaneously (although with a smaller weight) a supply factor. These variables considered as a group, however, are seen to be [illegible].

4. [illegible].-- In this study, price or quantity was expressed as a linear function of the shift variables or of their logarithms. By this it was implicitly assumed that the shifts of the demand schedule are parallel. At a time t the net relation between price and quantity is $p = aq + d_t$, or $\log p = a' \log q + d'_t$, where $d_t$ and $d'_t$ are the shift parameters of the demand schedule. It is evident that $d_t$ is a weighted average of the values of the shift variables at time t, and that $d'_t$ is a similar average of their logarithms -- the weights in both cases consisting of the coefficients of the shift variables.

The approximate character of this procedure must be emphasized. There is a temptation to attach too much significance to the specific form of the net relations, especially if the fit of the final equations is good. However, such functions [illegible] because of the uncertainty concerning the form of the net relations that are different, with equally admissible functions, were fitted. But it is not intended that this should imply that the true relations lie somewhere between the net relations described by the equations.

5. [illegible].-- If the statistical results of this paper are to be [illegible]

$$X_i = m_i + e_i \qquad (i = 1, 2, \ldots, N)$$
$$m_i = c_{1i}a_1 + c_{2i}a_2 + \ldots + c_{si}a_s$$

where the $X_i$'s are the N observations of the dependent variable, $m_i = E(X_i)$ is the expectation of $X_i$, the $e_i$'s are independent random variables with standard errors $\sigma_i = \sigma$ (unknown), [6] the $c_{ji}$'s are known numbers, and the $a_j$'s are unknown parameters. This specification makes possible the calculation of the best unbiased linear estimate of the dependent variable and of the unbiased estimate of its standard error. [7] Similarly, the unbiased estimate of the standard error of the coefficients of the above linear estimate (net regression coefficients) may also be calculated.

4. Tests of Significance.-- In the course of the investigation questions usually arise concerning the satisfactoriness of the equation as a whole and concerning the significance of the coefficients of the equation. Criteria either in terms of the standard error of the regression function or in terms of the standard error of the regression coefficients may be formulated by the investigator to answer such questions. For example, the equation may be deemed satisfactory if the ratio of the standard error of the equation to the estimated value is less than some number k. Or a given independent variable may be eliminated if the ratio of its coefficient to the standard error is less than a certain fixed value. The advantage of such "absolute" criteria is that they do not involve knowledge of the distribution function of the residuals $e_i$. Such tests, however, are in the main unsatisfactory

---

[6] More generally, $\sigma_i = B_i\sigma$ where $B_i$'s are known numbers. Throughout we assume that $B_i = 1$ $(i = 1, 2, \ldots, N)$.

[7] "Unbiased" in the sense that the mathematical expectation of the estimate is equal to the true value and "best" in the sense that of all unbiased linear estimates it has the smallest standard error. A detailed derivation of the estimate and of its standard error is given in: David, F. N. and J. Neyman. Extension of the Markoff theorem on least squares. Statistical Research Memoirs 2:105-116. 1938.

because of their extreme arbitrariness and because, without knowledge of the distribution functions, only very weak probability statements can be made.

The assumption that the residuals follow the normal law removes the arbitrariness inherent in the use of "absolute" criteria in multiple regression. However, such an assumption as to the distribution of the residuals may be considered arbitrary in that there are many other equally admissible assumptions about the probability function of the residuals. It may be desirable to consider the hypothesis most frequently tested in this paper, namely, that one of the parameters, say $a_s$, is zero in some detail so that the nature of the test may be properly appreciated.

Let U be the set of hypotheses ascribing to $a_1, \ldots, a_s, \sigma$ any real values with the restriction that $\sigma > 0$, and let u be a subset of U consisting of hypotheses specifying $a_s = 0$ but ascribing to the other parameters $a_1, \ldots, a_{s-1}, \sigma$ any real values $(\sigma > 0)$. According to the Neyman-Pearson principle of likelihood [8] the test of the hypothesis $a_s = 0$ should be based on the value of the ratio

$$L = p_u / p_U$$

or a constantly increasing or decreasing function of $L$, where $p_u$ is the maximum of the joint probability function of $(X_1, X_2, \ldots, X_N)$ relative to hypotheses contained in u, and $p_U$ a similar maximum probability relative to hypotheses contained in U. A low value of L implies that the set of observations $(X_1, \ldots, X_N)$ is much more probable on the basis of some hypothesis included in (U-u) than on the basis of the hypothesis tested and would thus lead to a rejection of the latter.

Direct calculations lead to the following expression for L, for the hypothesis tested $a_s = 0$:

$$L = (1 - r^2_{xs.})^{N/2}$$

where $r_{xs.}$ is the partial correlation coefficient. It is somewhat more convenient

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[8] Neyman, J. and E. S. Pearson. On the use and interpretation of certain test criteria for purposes of statistical inference. Part I. Biometrika 20A:175-240. 1928.

[illegible]
bution functions, only very weak probability statements can be made.

The assumption that the residuals follow the normal law removes the arbitrariness inherent in the use of "absolute" criteria in multiple regression. However, such an assumption as to the distribution of the residuals may be considered arbitrary in that there are many other equally admissible assumptions about the probability function of the residuals. It may be desirable to consider the hypothesis H as originally stated in this paper, namely, that one of the parameters, say $a_s$, is zero in some detail so that the nature of the test may be properly appreciated.

Let Ω be the set of hypotheses ascribing to $a_1, \dots, a_s$, σ any real values with the restriction that σ > 0, and let ω be a subset of Ω consisting of hypotheses specifying $a_s = 0$ but ascribing to the other parameters $a_1, \dots, a_{s-1}$, σ any real values (σ > 0). According to the Neyman-Pearson principle of likelihood [1] the test of the hypothesis $a_s = 0$ should be based on the value of the ratio

$$L = p_\omega / p_\Omega$$

or a monotonically increasing or decreasing function of L, where $p_\omega$ is the maximum of the joint probability function of $(X_1, X_2, \dots, X_N)$ relative to hypotheses contained in ω and $p_\Omega$ a [illegible] maximum probability relative to hypotheses contained in Ω. A low value of L implies that the set of observations $(X_1, \dots, X_N)$ is much more probable on the basis of some hypothesis not included in ω [illegible] of the hypothesis [illegible] rejection of the hypothesis.

[illegible]

[illegible]

$$L = (1 - r^2_{xs.})^{N/2}$$

where $r_{xs.}$ is the partial correlation coefficient. It is somewhat more convenient to use the following constantly decreasing function of $L$ ,

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[1] Neyman, J., and E. S. Pearson, "On the use and interpretation of certain test criteria for purposes of statistical inference," Part I., Biometrika, Vol. 20A, 1928.

$$L_1 = \left[(N-s)\ (L^{-2/N} - 1)\right]^{\frac{1}{2}} = \left[(N-s)\ \frac{r^2_{xs.}}{1-r^2_{xs.}}\right]^{\frac{1}{2}}$$

It will be recognized that $L_1$ is the ratio of the net regression coefficient of X on s to the unbiased estimate of its standard error. The distribution of this ratio for the case $a_s = 0$ is known, [9] and thus the probability of rejecting a true hypothesis may be reduced to any desired level.

It has been shown that a common best critical region for all admissible alternatives exists if the hypotheses in (U-u) specify $a_s > 0$ or $a_s < 0$. [10] This region is defined by the inequality $L_1 \geqq t_\alpha$ for $a_s > 0$ or by the inequality $L_1 \leqq - t_\alpha$ for $a_s < 0$. In these inequalities $t_\alpha$ is obtained from tables of the integral of the Student-Fisher t distribution for (N-s) degrees of freedom and for $\alpha$ (probability of rejecting a true hypothesis) based on one tail of the distribution. A test based on the best critical region is to be preferred to other tests because for any set level of significance, its power (the probability of rejecting the hypothesis when it is wrong) is not less than the power of any other test determined at the same level of significance.

The use of "standard errors" in connection with time-series data is frequently criticized by economists and statisticians. Aside from the question of the formal satisfaction by the data of the specific assumptions underlying the commonly used tests, much of the strength of the criticism is derived from a general feeling concerning the lack of realism in the basic specifications. The notion of a random sample when applied to describe a configuration of prices or quantities over time appears to be highly inappropriate, not only because the price or quantity

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[9] Fisher, R. A. Application of "Student's" distribution. Metron 5:90-104. 1925.

[10] Kolodziejczyk, S. On an important class of statistical hypotheses. Biometrika 27:161-190. 1935.

observations may be shown to be serially related, but because the sequence of prices or quantities appears to be unique. When separated from a consideration of the specific conditions which must be met by the data in each problem, such attitudes become an expression of the convictions of the investigator and are difficult to evaluate objectively.

The randomness of residuals with regard to time is a condition of importance in the application of classical regression methods to time-series data. The formal satisfaction of this condition in a given problem can be tested, at least approximately, and such tests have been carried out in this paper. The normality of residuals, however, was not actually tested since there were too few observations on which to base such a test.

[illegible]

The randomness of residuals with regard to time is a condition of importance in the application of classical regression methods to time-series data. The formal [illegible] of this condition in a given problem can be tested, at least approximately, and such tests have been carried out in this paper. The condition of [illegible], however, was not actually tested since there were too few observations to permit such a test.

## Demand for Summer Lemons

The shift variables considered explicitly in the analysis of demand for lemons during the summer months were consumer income, index of temperatures, time, and volume of production. Of these only the first two variables proved to be statistically significant, but there are indications that such trend factors as growth of population during the period under review, advertising, etc., did exert an influence on the demand for summer lemons in this country.

Consumer Income. In table 1 is given the average weekly consumption of lemons by income class obtained in some of the regional samples of the 1935-36 Consumer Purchases Study. It is seen that in these samples the relation between family income and consumption of lemons is positive and that for the range of income considered, the relation is approximately linear.[11] It would have been of interest to combine such budget data with time series "market" data on prices and quantities as suggested recently by Marschak.[12] In this manner additional information provided by the budget data could be utilized. However, while this approach may be suitable in a study of demand for goods at the retail level, it is not well adapted to analyses of demand at other stages of the marketing process. The existence, at a given time, of a relation between consumer income and lemon consumption is, therefore, used here only to suggest that consumer income may be an important factor affecting demand for lemons.

For a description of the particular income index employed (index of nonagricultural income payments) and a discussion of its limitations, the reader is referred to appendix A. Here it should be pointed out that both prices and income are used throughout this study in current dollars -- no attempt has been made to deflate these series. It is largely a matter of individual preference as to whether demand is to be defined in money or in real (deflated) prices.[13] It may be deemed desirable to eliminate from prices changes associated with the movement of the general price level and to consider the effect on demand for a specific commodity of changes in real rather than money incomes. However, the crude adjustments commonly employed for this purpose are of questionable validity; their use may actually distort the relations which the analysis seeks to describe.

Weather. The effect of weather on the demand for summer lemons has long been observed by the trade. Since the principal use of lemons during the

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[11] A similar relation is found in the September-November data for regions cited in table 1 and in the village and farm samples tabulated by the Bureau of Home Economics. See: United States Bureau of Home Economics. Family food consumption and dietary levels. Farm series. Misc. Pub. 405. Urban and village series. Misc. Pub. 452. Washington, D.C., 1941.

[12] Marschak, J. Money illusion and demand analysis. Review of Economic Statistics 25:40-48. February, 1943.

[13] Working, E. J. Indications of changes in the demand for agricultural products. Jour. Farm Econ. 14:239-256. 1932.

## [illegible]

The chief variables considered explicitly in the analysis of demand for [illegible] during the base period were consumer [illegible] index of consumer [illegible], and volume of production. Of these only the first two variables proved to be statistically significant, but there are indications that such other factors as levels of [illegible] [illegible], etc., may [illegible] influence on the demand [illegible] economy.

[illegible]

[illegible]

[illegible]

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[illegible]

[illegible] February, 1948.

[illegible]

## TABLE 1

### Weekly Average Consumption of Lemons by Native-White Nonrelief Families Classified by Income and Region, Selected Cities, May-August, 1936

| Income class | Average weekly family consumption of lemons | | | | |
|---|---|---|---|---|---|
| | New York City and Chicago | New England and East Central | Southeast | West Central and Rocky Mountain | Pacific North-west |
| Dollars | Dozens | | | | |
| 500- 999 | .07 | .06 | .28 | .08 | .08 |
| 1,000-1,499 | .12 | .13 | .45 | .15 | .14 |
| 1,500-1,599 | .11 | .17 | .53 | .21 | .14 |
| 2,000-2,999 | .21 | .20 | .64 | .25 | .26 |
| 3,000-3,999 | .27 | .38 | .78 | .33 | .37 |
| 4,000-4,999 | .21 | .41 | .94 | .47 | .39 |

Source of data:

United States Bureau of Labor Statistics. Study of consumer purchases. Family expenditures in selected cities, 1935-36. Volume 11: Food. Bulletin No. 648. Govt. Print. Off. Washington, D. C. 1940.

summer months is in cooling beverages, weather conditions affecting consumption of cold drinks may also be expected to affect the demand for lemons.

It is unlikely that temperature is the only weather factor affecting the summer demand for lemons. Other factors such as relative humidity, amount of precipitation, wind velocity, hours of sunshine, etc., may be required to measure properly the effect of weather. Furthermore, each of these variables is in itself complex, and various characteristics of their temporal distribution would have to be examined to determine the most appropriate measure or combination of measures to be employed. With the few observations at our disposal, it was obviously unwise to attempt a comprehensive coverage of these factors. In the analyses to be described, we have used the average, for a number of cities, of daily positive departures of maximum temperatures from an arbitrary reference point to represent the weather variable. A mention of the reasons leading to the choice of this measure will be found in appendix A.[14]

Trend Factors. Under the rubric "trend factors" are included demand influences whose aggregate effect is to change the demand for lemons slowly and smoothly. During the twenty years under consideration the population of the continental United States increased by some 25 millions of persons; extensive advertising of lemons was carried on yearly, new outlets and better marketing facilities were developed. It is reasonable to assume that in the aggregate such factors have increased the demand for lemons slowly and smoothly. Because of the difficulty of measuring the separate net effects of such variables, only their aggregate contribution can be considered.[15]

It is usual in statistical demand studies based on time series data to account for the influence of trend factors by the introduction of a "time" variable. This practice has been followed in the present study. In the correlation of time series the variable "time" has also a more formalistic duty to perform, namely to randomize residuals. It is, of course, highly desirable that the contribution of "time" be minor relative to the contribution of the other more explicit independent variables; otherwise a large part of the variance of the dependent variable is allocated to factors not properly identified.

Volume of Domestic Production. The variables we have considered thus far are factors which might reasonably be expected to affect the consumer demand for lemons. The statistical analyses reported in this paper, however, are oriented not toward consumer demand, but toward the derived demand, at the f.o.b. level, facing handlers of lemons. Hence, factors unrelated to consumer demand, but directly affecting the derived demand must also be considered. Such factors are certainly more difficult to measure than those already discussed. While it was not possible to undertake a thorough study of these variables, some attempts have been made to test their influence.

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[14] Another temperature index is described in appendix E.

[15] The influence of the population factor was partly eliminated in some of the regression equations described below by the use of per-capita data. Such an adjustment, however, obviously ignores the effect of changes in the age distribution of the population.

Knowledge (expectations) by dealers of the volume of lemons available for disposal as fresh fruit may exert a net influence on the level of f.o.b. prices. In years of unusually large crops a given level of shipments may result in prices substantially lower than those called forth in years of short crops (factors affecting consumer demand remaining constant) by an identical level of shipments. A widespread expectation of an unusually large crop may create an unwillingness on the part of dealers to buy extensively in the present market because of the anticipation of a fall in prices. On the other hand, a widespread knowledge among dealers of the shortness of the crop may induce a willingness to pay "scarcity" prices even though the supply of lemons in the wholesale markets may be ample. A striking illustration of the operation of this mechanism is described in the next section.

The measurement of the influence of this variable is complicated by the fact that since 1924 marketing agreements containing provisions for limitation of shipments have been in effect in the lemon industry. Because of the presence of control over volume of shipments, it is possible that a greater expression of this factor is to be found in years characterized by short crops than in years of large crops. However, until 1941 marketing agreements were not industry-wide. Furthermore, in years of large crops, grower pressure to increase shipments regardless of demand conditions may be expected. Whatever the reasons, the fact is that, for the period under review, the year-to-year fluctuations in production were significantly related to the year-to-year fluctuations in quantity shipped. 16/ A large crop, then, has meant more often than not large shipments and hence anticipated low prices.

Volume of Imports. Mention has already been made of the fact that during the first half of the period under review large quantities of lemons were imported into this country. This source of supply, obviously, cannot be left out of consideration in a demand study, even though the problems created by imports are now only of historical interest. Little is known concerning the substitutability relations between imported and domestic lemons; hence not much can be said concerning the expected direction and degree of influence of the import variable. The statistical analysis may throw some light on the above-mentioned relationships.

The series used in the analysis of demand for summer lemons are given in table 2. A linear form expressing f.o.b. prices as a function of total United States supply of lemons, nonagricultural income payments, and the temperature index was found to fit the data rather closely (see equation 1s, table 3). An examination of the scattering of residuals about the various net regression lines, shown in figure 3, appendix C, did not reveal marked departures from linearity. 17/

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16/ The correlation between first differences in industry annual shipments and first differences in annual production is .55.

17/ The charts given in appendix C were constructed by drawing a trace of the regression surface in a plane with the dependent variable measured on the vertical axis and each of the independent variables measured on the horizontal axis. The points represent the residuals (see table 26, appendix B) as calculated from the regression equation, plotted as deviations from the net regression line corresponding to the values of the independent variable at which they were calculated.

Knowledge (expectations) by dealers of the volume of lemons available for [illegible] in years of unusually large crops a given level of shipments may result in prices substantially lower than those called forth in years of short crops [illegible] of shipments. A widespread expectation of an unusually large crop may create an unwillingness on the part of dealers to buy extensively in the present market [illegible] sale markets may be made. A striking illustration of the operation of this mechanism is described in the next section.

The measurement of the influence of this variable is complicated by the fact that since 1924 marketing agreements containing provisions for limitation of shipments have been in effect in the lemon industry. Because of the presence of control over volume of shipments, it is possible that a greater expression of this factor is to be found in years characterized by short crops than in years of large crops. However, until 1941 marketing agreements were not in- [illegible] shipments and hence unusually low prices.

[illegible]

The series used in the analysis of demand for summer lemons are given in [illegible]

[illegible] found to fit the data rather closely (see equation 15, table 5). An examination of the scattering of residuals about the various net regression lines, shown in figure 5, appendix C, did not reveal marked departures from linearity.17/

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16/ [illegible] first differences in annual production is [illegible].

17/ [illegible] the values of the independent variable at which they were calculated.

TABLE 2

Summer Lemons: Basic Series Used in the Demand Analysis, 1922-1941

| Year May-October | F.o.b. price $x_1$ | United States supply $x_2$ | Per capita United States supply $x_2^o$ | Domestic shipments $x_{2d}$ | Imports for consumption $x_{2i}$ | C.F.G.E. domestic shipments $x_{2e}$ | Outside supply $x_{2o}$ | Index of nonagricultural income * $x_3$ | Per capita nonagricultural income $x_3^o$ | Index of temperatures † $x_4$ |
|---|---|---|---|---|---|---|---|---|---|---|
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|  | dollars per box | 10,000 boxes | pounds | 10,000 boxes | 10,000 boxes | 10,000 boxes | 10,000 boxes | per cent | per cent | per cent |
| 1922 | 4.48 | 328 | 2.27 | 235 | 93 | 201 | 127 | 88 | 88 | 100 |
| 1923 | 5.23 | 312 | 2.13 | 202 | 110 | 193 | 119 | 100 | 97 | 92 |
| 1924 | 2.74 | 369 | 2.48 | 322 | 47 | 276 | 93 | 101 | 96 | 80 |
| 1925 | 4.93 | 399 | 2.64 | 289 | 110 | 267 | 132 | 110 | 103 | 120 |
| 1926 | 3.23 | 403 | 2.63 | 328 | 74 | 300 | 103 | 113 | 103 | 88 |
| 1927 | 4.88 | 351 | 2.26 | 289 | 62 | 259 | 92 | 116 | 104 | 75 |
| 1928 | 4.86 | 350 | 2.22 | 303 | 47 | 281 | 69 | 119 | 104 | 89 |
| 1929 | 5.36 | 355 | 2.22 | 322 | 33 | 292 | 63 | 123 | 106 | 105 |
| 1930 | 5.18 | 388 | 2.40 | 333 | 55 | 308 | 80 | 111 | 94 | 138 |
| 1931 | 4.50 | 399 | 2.44 | 381 | 18 | 348 | 51 | 96 | 81 | 150 |
| 1932 | 4.41 | 312 | 1.90 | 307 | 5 | 283 | 29 | 74 | 62 | 110 |
| 1933 | 3.60 | 354 | 2.14 | 347 | 7 | 311 | 43 | 71 | 59 | 136 |
| 1934 | 3.85 | 406 | 2.44 | 404 | 2 | 368 | 38 | 81 | 67 | 142 |
| 1935 | 3.39 | 416 | 2.48 | 416 | -- | 380 | 36 | 87 | 71 | 106 |
| 1936 | 4.51 | 431 | 2.56 | 427 | 4 | 408 | 23 | 104 | 85 | 151 |
| 1937 | 4.86 | 387 | 2.28 | 384 | 3 | 369 | 18 | 108 | 87 | 127 |
| 1938 | 2.87 | 435 | 2.55 | 435 | -- | 414 | 21 | 99 | 79 | 115 |
| 1939 | 3.17 | 470 | 2.73 | 470 | -- | 445 | 25 | 107 | 85 | 140 |
| 1940 | 3.04 | 461 | 2.66 | 461 | -- | 422 | 39 | 114 | 90 | 106 |
| 1941 | 3.19 | 550 | 3.14 | 550 | -- | 507 | 43 | 135 | 105 | 145 |
| $\bar{x}$ | 4.114 | 393.8 | 2.429 | 360.2 | 33.4 | 331.6 | 62.2 | 102.9 | 88.3 | 115.8 |
| $\sigma_x$ | 0.860 | 56.5 | 0.264 | 82.5 | 37.9 | 79.7 | 36.4 | 16.0 | 11.4 | 23.6 |

* 1935-39 = 100.

† 1922 = 100.

Sources of data: Col. 1: Table 13.
Cols. 2, 3, 4, and 5: Table 18.
Cols. 6 and 7: Table 21.
Cols. 8 and 9: Table 22.
Col. 10: Table 23.

## TABLE 3

Summer Lemons: Regression Coefficients and Auxiliary Constants, 1922-1941
(Figures in parentheses are standard errors)

| Equation | Dependent variable | Net regression coefficients * | | | | | Adjusted coefficient of multiple correlation | Elasticity of demand | Flexibility of price |
|---|---|---|---|---|---|---|---|---|---|
| | | Constant term | F.o.b. price | United States supply | Nonagricultural income | Index of temperatures | | | |
| | $F_{(x)}$ | c | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $\bar{R}$ | η † | φ † |
| 1s | $x_1$ | 4.3482 | | -0.0205<br>(0.0022) | 0.0445<br>(0.0067) | 0.0282<br>(0.0047) | 0.9050 | | -1.9620 |
| 2s | $x_2$ | 185.6147 | -41.2473<br>(4.4092) | | 2.1239<br>(0.2387) | 1.3774<br>(0.1607) | 0.9569 | -0.4309 | |
| | | | | Per capita United States supply | Per capita nonagricultural income | | | | |
| | $F_{(x)}$ | c | $x_1$ | $x_2^o$ | $x_3^o$ | $x_4$ | $\bar{R}$ | η † | φ † |
| 3s | $x_1$ | 4.8712 | | -3.6617<br>(0.3990) | 0.0565<br>(0.0075) | 0.0272<br>(0.0046) | 0.9089 | | -2.1615 |
| 4s | $x_2^o$ | 1.2413 | -0.2295<br>(0.0250) | | 0.0146<br>(0.0016) | (0.0073<br>(0.0010) | 0.9401 | -0.3888 | |
| | $F_{(x)}$ | c | Log $x_1$ | Log $x_2$ | Log $x_3$ | $x_4$ ‡ | $\bar{R}$ | η | φ |
| 5s | Log $x_1$ | 3.5555 | | -2.0854<br>(0.2385) | 1.0356<br>(0.1747) | 0.0074<br>(0.013) | 0.8922 | | -2.0854 |
| 6s | Log $x_2$ | 1.6757 | -0.3965<br>(0.0454) | | 0.4865<br>(0.0613) | 0.0036<br>(0.0004) | 0.9507 | -0.3965 | |

(Footnotes on next page)

Table 3 continued:

* $x_1$ = Seasonal average f.o.b. price in dollars per box.

$x_2$ = United States supply of lemons in units of 10,000 boxes.

$x_2^o$ = Per capita United States supply of lemons in pounds.

$x_3$ = Index of nonagricultural income payments, 1935-39 = 100.

$x_3^o$ = Per capita index of nonagricultural income payments in per cent.

$x_4$ = Index of daily maximum temperature departures from 80° in 39 metropolitan districts, May through October.

† At the centroid.

‡ In natural logarithms.

A linear equation expressing the United States supply of summer lemons as a function of the f.o.b. prices, nonagricultural income, and the index of summer temperatures (see equation 2s, table 3) was found to give an excellent fit to the data. With supply as the dependent variable, the adjusted multiple correlation coefficient is 0.9569 which is markedly higher than the corresponding coefficient of 0.9050 with price as the dependent variable. The scatters of supply residuals about the various net regression lines are shown in the panels of figure 4, appendix C. It is evident from these charts that the use of curved net regressions would not markedly improve the fit of the equation.

The results of tests of randomness of residuals derived from the two equations are found in table 27, appendix B. Neither the magnitudes of the lagged correlation coefficients nor the probabilities derived from the Wallis-Moore test force the rejection of the hypothesis that the residuals constitute a random series.

In both equations 1s and 2s -- as, in fact, in all of the regression equations discussed in this paper -- the signs of the net regression coefficients agree with the direction of influence expected on a priori grounds. Nonagricultural income payments and the temperature index are related directly to both the f.o.b. prices and the United States supply of summer lemons, while the two latter variables are related inversely. The inverse net price-supply relationship is, of course, in agreement with the demand relationship discussed in theoretical economics. The direct variation of both prices and quantities with income and temperature is also entirely reasonable. An increase in purchasing power should express itself either in higher prices of lemons, if the quantity of lemons purchased remains constant, or in larger quantities of lemons purchased if the price remains constant. A similar relation is evident for the seasonal demand factor, temperature.

Of some interest is the determination of the relative contribution of the several independent variables. In almost all statistical demand studies the two variables of prime importance are price and quantity; the investigator usually

expects a significant part of the variation in price to be associated with the variation in the amount sold, and inversely. The supply-price relationship is also the most strategic from the point of view of policy, for these are ordinarily the only two variables in the formulation which are capable of being controlled. Of interest is also the contribution of the temperature factor to price and supply variance, since this non-economic seasonal factor has been given great prominence in the discussions of the demand for summer lemons found in trade publications.

The net regression coefficients in the two equations cited above cannot be taken as they stand to measure the contribution of the independent variables in "accounting" for the price or supply variance. In fact, the problem of measuring the relative importance of independent variables may not have a unique solution; certainly, none of the measures at present available can be deemed satisfactory. Of the several measures of relative importance commonly employed, the coefficient of separate determination, $d_{ij} = \beta_{ij} r_{ij}$, is, probably, the least ambiguous because of its additive property, $\sum_{j=1}^{m} d_{ij} = R_i^2$, where $R_i$ is the multiple correlation coefficient. The ambiguity introduced by the occasional appearance of negative values of $d_{ij}$ can be removed by a minor adjustment which does not disturb the additive property of this coefficient.[18]

The first two rows of table 4 give the coefficients of separate determination for equations 1s and 2s. It will be observed that either f.o.b. price or the quantity of summer lemons accounts for the major part of the variance of the dependent variable. This is particularly evident in equation 1s in which approximately 73 per cent of the variance of f.o.b. prices is allocated to the United States supply, 9 per cent to nonagricultural income, and only 2 per cent to the temperature variable.

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[18] The adjustment is of the form $d_{ij}^{o} = |d_{ij}| \frac{\sum d_{ij}}{\sum |d_{ij}|}$, $(i \neq j)$.

[illegible]

Of interest is also the contribution of the temperature factor to price and supply variance, since this non-economic seasonal factor has been given great prominence in the discussions of the demand for summer lemons found in trade publications.

The net regression coefficients in the two equations cited above cannot be taken as they stand to measure the contribution of the independent variables in "accounting" for the price or supply variations. In fact, the problem of measuring [illegible] certainty, none of the measures at present available can be deemed satisfactory. Of the several measures of relative importance commonly employed, the coefficient of separate determination, $d_{ij} = \beta_{ij} r_{ij}$, is, probably, the least ambiguous because of its additive property, $\sum d_{ij} = R^2$, where $r_{ij}$ is the [illegible] correlation coefficient. The ambiguity introduced by the occasional appearance of negative values of $d_{ij}$ can be removed by a minor adjustment which does not disturb the additive property of this measure.[1]

The first two rows of table 4 give the coefficients of separate determination for equations 1a and 2a. It will be observed that either f.o.b. price or the quantity of summer lemons accounts for the major part of the variance of the dependent variable. [illegible] approximately 7[illegible] per cent of the variance of f.o.b. prices is allocated to the United States supply, [illegible]

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[1] The adjustment is of the form [illegible]

## TABLE 4

Summer Lemons: Coefficients of Separate Determination

| Equation | Dependent variable | F.o.b. price $x_1$ | United States supply $x_2$ | Per capita United States supply $x_2^o$ | Index of nonagricultural income $x_3$ | Per capita nonagricultural income $x_3^o$ | Index of temperatures $x_4$ |
|---|---|---|---|---|---|---|---|
| | | Per cent | | | | | |
| 1s | $x_1$ | | 73.4 | | 9.4 | | 2.0 |
| 2s | $x_2$ | 35.9 | | | 27.3 | | 29.7 |
| 3s | $x_1$ | | | 58.8 | | 24.7 | 1.9 |
| 4s | $x_2^o$ | 41.1 | | | | 26.5 | 22.6 |
| 5s | Log $x_1$ | | 75.6 | | 6.8 | | 0.4 |
| 6s | Log $x_2$ | 35.7 | | | 24.7 | | 31.6 |

Source of data:

Based on equations 1s through 6s given in table 3. Coefficients based on equations 1s and 3s adjusted to remove negative signs.

The variance of quantity is partitioned more evenly among the independent variables in equation 2s; the allocations to f.o.b. price, income, and temperature variables are respectively 36 per cent, 27 per cent, and 30 per cent. Not much confidence can be felt in the reversal of the relative importance of the income and temperature factors in the two equations, for such results are not obtained when other measures of relative importance are employed. [19]

In view of the great prominence given weather factors in trade descriptions of the behavior of prices of summer lemons, it is somewhat surprising to find that the foregoing rough measures assign relatively little importance to the temperature variable. [20] However, it is doubtful whether the total effect on demand for lemons of changes in weather conditions has been or could be ascertained by means of the temperature index we have employed. As was stated previously, temperature is not the only condition of relevance; furthermore, only one measure of the temperature variable was used. On the other hand, the possibility that the effect of weather has been given undue emphasis in trade discussions of interseasonal variation of lemon prices and shipments cannot be ruled out of consideration. [21]

The values of the coefficient of flexibility of price calculated from equation 1s at the centroid and of the coefficient of elasticity of demand calculated from equation 2s, similarly at the centroid, are given in table 3.[22] Demand for

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[19] The squares of the pertinent partial correlation coefficients are: $r^2_{12.34} = 0.8454$, $r^2_{13.24} = 0.7350$, $r^2_{14.23} = 0.6910$, $r^2_{23.14} = 0.8319$, and $r^2_{24.13} = 0.8212$.

[20] With regard to goodness of fit of the equations, temperature is an important variable, for its omission results in a marked reduction of fit. For example, with temperature omitted the adjusted coefficient of multiple correlation (price dependent) is only 0.6699 -- a considerable reduction from its former value of 0.9050.

[21] The statistical results pertain to interseasonal behavior of prices and quantities; temperature may well be the major factor affecting the intraseasonal variation of prices and shipments.

[22] $\varphi = \frac{\partial x_1}{\partial x_2} \frac{\bar{x}_2}{\bar{x}_1} = b_{12} \frac{\bar{x}_2}{\bar{x}_1}$ and $\eta = \frac{\partial x_2}{\partial x_1} \frac{\bar{x}_1}{\bar{x}_2} = b_{21} \frac{\bar{x}_1}{\bar{x}_2}$, where the $\bar{x}$'s are means and $b_{ij}$ is the net regression coefficient (i denoting the dependent

(Continued on next page)

The variance of [illegible] is distributed more evenly among the ingredients varying in equation (3); the proportions to T.F.P., wages, income, and [illegible] variables are respectively 50 per cent, 4½ per cent, and [illegible] per cent. Not much confidence can be put in the appraisal of the relative importance of the [illegible] these factors in the two equations, for such results are not [illegible] when measures of relative importance are employed.12/

In view of the high correlations among variables found in time series descriptions of the behavior of various types of consumer income, it is somewhat surprising to find that the [illegible] assign relatively little importance to the [illegible] variables.13/ However, it is doubtful whether the total effect on demand for [illegible] of changes in consumer expenditures can [illegible] could be measured only by means of the [illegible] index we have employed. As was noted previously, [illegible] is not the only condition of [illegible]; only one measure of the [illegible] variable was used. On the other hand, the possibility that the effect of [illegible] has been given undue [illegible] in [illegible] of [illegible] prices and [illegible] of [illegible].14/

The [illegible] of the coefficients of [illegible] and [illegible] coefficient of [illegible] with [illegible] are given in table [illegible]. [illegible]

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11/ The squares of the coefficients of partial correlation are: $r^2_{13.24}$ = [illegible], $r^2_{14.23}$ = [illegible], $r^2_{12.34}$ = [illegible], and $r^2$ = [illegible].

12/ With regard to [illegible] of the [illegible] in [illegible] variables, [illegible] is only 0.093 [illegible].

13/ The statistical results appear to [illegible] behavior of prices and [illegible] individual variation of prices and [illegible].

14/ [illegible]

[illegible] is the [illegible] (Continued on next page) summer lemons at the f.o.b. level, based on these equations and measured at the centroid, is seen to be inelastic. Since in the linear formulation the values of flexibility and elasticity change from point to point on the regression hyperplane, it is of interest to consider the magnitudes of the coefficients of flexibility and elasticity in each of the years included in the analysis.[23] As can be seen from the enclosed tabulation (table 5), the absolute values of the seasonal coefficients of flexibility are all greater than 1 and correspondingly the absolute values of the seasonal coefficients of elasticity are all less than 1. While the reciprocals of the coefficients of flexibility do not agree exactly with the values of the elasticity coefficients, differences are to be expected from the very nature of the two estimation equations. It will be noted further that there is a trend in the calculated values of $\varphi$ . This trend is due to the upward trend in supply, for it is the property of negatively sloped linear demand laws that flexibility increases with an increase in quantity.[24] Obviously, the trend in the calculated values of $\eta$ is opposite to that for $\varphi$ .

The findings with regard to coefficients of elasticity and flexibility accord with _a priori_ expectations concerning the nature of the demand for lemons. Lemons are used in various drinks, in cooking and baking, for flavoring and seasoning, as garnish, as salad dressing, and as hair rinse. In all but a few uses lemons are

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(Footnote 22/ continued)

variable). For significance tests in connection with $\varphi$ and $\eta$ see: Girshick, M.A. The application of the theory of linear hypotheses to the coefficient of elasticity of demand. Jour. Amer. Stat. Assn. 37:233-237. 1942.

[23] The values of $\varphi$ and $\eta$ for year t were calculated from the expressions $\varphi_t = b_{12} \frac{x_{2t}}{x'_{1t}}$ and $\eta_t = b_{21} \frac{x_{1t}}{x'_{2t}}$ where $x'_{1t}$ is the estimated f.o.b. price for the year t calculated from equations 1s and $x'_{2t}$ is the estimated supply calculated from equation 2s.

[24] It is possible, however, with a multidimensional linear equation that $\varphi$ is not a monotonically increasing function of quantity.

## TABLE 5

Summer Lemons: Calculated Coefficients of Price Flexibility and Demand Elasticity, 1922-1941

| Year May-October | Price flexibility $\varphi$ | Demand elasticity $\eta$ | Per capita formulation | |
|---|---|---|---|---|
| | | | Price flexibility $\varphi$ | Demand elasticity $\eta$ |
| | 1 | 2 | 3 | 4 |
| 1922 | -1.4668 | -0.5678 | -1.9558 | -0.4611 |
| 1923 | -1.2803 | -0.6981 | -1.5444 | -0.5635 |
| 1924 | -2.1408 | -0.2845 | -2.6788 | -0.2418 |
| 1925 | -1.8397 | -0.5335 | -2.2533 | -0.4544 |
| 1926 | -2.2974 | -0.3221 | -2.7914 | -0.2808 |
| 1927 | -1.6245 | -0.6027 | -1.8349 | -0.5114 |
| 1928 | -1.4414 | -0.5561 | -1.6129 | -0.4871 |
| 1929 | -1.3222 | -0.5969 | -1.4542 | -0.5302 |
| 1930 | -1.5228 | -0.5371 | -1.7097 | -0.4892 |
| 1931 | -1.7522 | -0.4521 | -1.9465 | -0.4165 |
| 1932 | -1.4719 | -0.5823 | -1.5776 | -0.5244 |
| 1933 | -1.7772 | -0.3957 | -1.9300 | -0.3656 |
| 1934 | -2.2918 | -0.4026 | -2.4957 | -0.3728 |
| 1935 | -3.1826 | -0.3713 | -3.3884 | -0.3427 |
| 1936 | -2.0098 | -0.4342 | -2.1304 | -0.4059 |
| 1937 | -1.6527 | -0.5147 | -1.7073 | -0.4808 |
| 1938 | -2.8976 | -0.2716 | -2.9927 | -0.2563 |
| 1939 | -2.8169 | -0.2753 | -2.8725 | -0.2626 |
| 1940 | -3.1942 | -0.2797 | -3.1420 | -0.2653 |
| 1941 | -3.5595 | -0.2435 | -3.5378 | -0.2362 |

Source of data:

Calculated from equations 1s, 2s, 3s, and 4s respectively for the values of the independent variables which prevailed in the various years.

an important ingredient but at the same time a minor element of the cost of the total product. This would lead one to expect that consumption of lemons is not highly responsive to changes in their prices, that is, that the demand for lemons is inelastic.

The use of equations 1s and 2s for estimation purposes should be accompanied by some measure of the uncertainty of the estimate. The unbiased estimates of the variance of the best linear unbiased estimate of $x_1$ and $x_2$ are given herewith.[25/]

$$\mu_{f_1}^2 = 0.0070 + 0.0153\, z_2^2 + 0.0115\, z_3^2 + 0.0124\, z_4^2 - 0.0162\, z_2 z_3 - -0.0179\, z_2 z_4 + 0.0113\, z_3 z_4$$

and

$$\mu_{f_2}^2 = 14.18 + 14.39\, z_1^2 + 14.62\, z_3^2 + 14.43\, z_4^2 - 3.36\, z_1 z_3 + +0.335\, z_1 z_4 + 3.72\, z_3 z_4$$

where the $z_i$'s are the "normalized" values of the independent variables for which $x_1$ or $x_2$ is estimated. The statistical uncertainty accompanying the estimate $x'$ is then expressed in the form of the confidence interval $x' - t_\alpha \mu_f \leq \theta \leq x' + t_\alpha \mu_f$ where $t_\alpha$ is the Student-Fisher t at the level of significance $\alpha$, and $1 - \alpha$ is the confidence coefficient. The expressions for $\mu_f^2$ will not be stated explicitly for the other estimation equations to be considered in this section. However,

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[25/] $\mu_{f_1}^2 = \dfrac{\sigma_1^2\, |R|\, |D|}{(N-n)\, |R_{11}|^2}$ where $|R|$ is the determinant of the matrix of intercorrelations between the n variables, $|R_{11}|$ is the minor of $r_{11}$ in $|R|$, $|D|$ is the determinant of the matrix

$$D = \begin{bmatrix} -1 & z_2 & z_3 & \cdots & z_n \\ z_2 & 1 & r_{23} & \cdots & r_{2n} \\ z_3 & r_{23} & 1 & \cdots & r_{3n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ z_n & r_{2n} & r_{3n} & \cdots & 1 \end{bmatrix}$$

and $z_i = \dfrac{1}{\sigma_i}(x_i - \bar{x}_i)$. The formula for $\mu_{f_1}^2$ used here is equivalent to the expression derived in: **David**, F. N. and J. Neyman. Extension of the Markoff theorem on least squares. Statistical Research Memoirs 2:105-116. 1938.

sufficient information is given in this paper to enable the calculation of the standard error of the regression equation for any of the estimation equations given in tables 3 and 8. Attention should also be drawn to the fact that $(\mu_{f_i}^2 + S_i^2)$, where $S_i^2$ is the unbiased estimate of the variance of each $x_i$, is the appropriate variance for determining the confidence limits of the future observation. [26]

An attempt was made to introduce a measure of the factor discussed in previous pages under the rubric "volume of production." First differences in annual production of lemons and first differences in California Fruit Growers Exchange lemon picks and the Exchange May 1 storage were not found to be related to either price or quantity residuals secured from equations 1s and 2s respectively. These measures, then, if introduced as additional independent variables in the equations would not reduce significantly the "unexplained" variance of the dependent variable. [27] However, first differences in Exchange May-October lemon picks appeared to be related to price and quantity residuals. It is difficult to see why first differences in picks alone should bear a significant net relation to prices or shipments, since May 1 storage has been an important constituent of the supply of lemons available for shipments during the summer months. Because complete data on

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[26] See Eisenhart, C. The interpretation of certain regression methods and their use in biological and industrial research. Annals of Math. Stat. 10:162-186. 1939. Also, Ezekiel, Mordecai. Methods of correlation analysis. Second edition. Chapter 19. John Wiley & Sons, Inc., New York. 1941.

[27] Let j be the additional independent variable under consideration and i the dependent variable. Then

$$t = b_{ij} / s_{b_{ij}} = r_{zj} \sqrt{(N-n) / (1-R_j^2)}$$

where $r_{zj}$ is the correlation between residuals and the additional variable, $R_j$ is the coefficient of multiple correlation between j and the other variables including i, N is the number of observations, and n the number of constants in the regression equation. The magnitude of t may be deduced from this expression knowing $r_{zj}$ and assigning some plausible value to $R_j$.

lemon picks for the period under review were not available at the time these calculations were made, further consideration of this factor was not attempted. [28]

An attempt was also made to account for the influence of the trend factors by introducing "time" as a separate variable in the estimation equations. In the equations given below, $x_1$ is f.o.b. price, $x_2$ United States supply of summer lemons, $x_3$ index of nonagricultural income payments, $x_4$ the index of summer temperatures, and $x_5$ "time" measured in units of six months from an origin midway between 1931 and 1932. The figures in parentheses are standard errors of the net regression coefficients. It is seen that the added variable does not have a significant influence. With f.o.b. price as the dependent variable, the standard error of the coefficient of $x_5$ is greater than the coefficient. In the other equation, the ratio of the coefficient of $x_5$ to its standard error ($t = 1.586$) falls short of the value of t corresponding to the 5 per cent level for 15 degrees of freedom ($t_{.05} = 2.131$).

$$x_1' = 4.5214 - \underset{(0.0030)}{0.0210}\, x_2 + \underset{(0.0072)}{0.0450}\, x_3 + \underset{(0.0050)}{0.0279}\, x_4 + \underset{(0.0129)}{0.0032}\, x_5$$

$$x_2' = 206.4872 - \underset{(5.2356)}{36.3209}\, x_1 + \underset{(0.2424)}{1.9942}\, x_3 + \underset{(0.2157)}{1.1373}\, x_4 + \underset{(0.4988)}{0.7911}\, x_5$$

As will be indicated in some detail below, "time" was found to be an important factor in the analysis of the data on winter lemons. The question naturally arises as to why trend factors fail to play a role in the analysis of the demand for lemons during the summer months. Should it be concluded that the factors which "time" is presumed to represent did not affect the demand for summer lemons during the period under consideration?

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[28] The scatter diagrams of residuals against first differences in picks were based on only eighteen observations.

A partial answer to this question is found in the happenstance that the index of temperatures exhibits an upward trend during the period under review. This trend may have, to some extent, played the part of the catch-all "time" variable. A further circumstance to be considered in this connection is that the quantity variable used in the summer equations consisted of domestic shipments of lemons plus imports for consumption; whereas in the winter equations the quantity variable consisted only of domestic shipments. The use of United States supply, rather than domestic shipments, as the quantity variable makes the trend factors less important, because the trend in imports in the period under consideration runs exactly counter to the strong upward trend in domestic shipments.[29] The results secured when domestic shipments of summer lemons are employed together with "time" constitute an empirical confirmation of this point. These equations, both with price and with domestic shipments ($x_{2d}$) as the dependent variables, are given below. The figures in parentheses are standard errors.

$$x_1' = 5.492 - \underset{(0.0030)}{0.0209}\, x_{2d} + \underset{(0.0062)}{0.0320}\, x_3 + \underset{(0.0049)}{0.0247}\, x_4 + \underset{(0.0207)}{0.0691}\, x_5$$

$$x_{2d}' = 253.95 - \underset{(5.2951)}{36.3242}\, x_1 + \underset{(0.2451)}{1.3769}\, x_3 + \underset{(0.2182)}{0.9857}\, x_4 + \underset{(0.5045)}{3.9632}\, x_5$$

"Time" ($x_5$) is now significant in both equations and the adjusted multiple correlation coefficients, 0.8969 for price dependent and 0.9813 with domestic shipments as the dependent variable, are of about the same magnitude as those previously secured. Thus it is questionable whether economic meaning should be read into the failure of "time" to contribute significantly to the fit of the summer equations.

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[29] The following equations represent the linear trend in domestic shipments of summer lemons and United States supply of summer lemons, respectively. Both quantity series are in units of 10,000 boxes.

$$x_{2d}' = 360.23 + 6.5921\, t \quad \text{(Domestic shipments)}$$

$$x_2' = 393.80 + 3.6865\, t \quad \text{(United States supply)}$$

It appears rather that the explanation lies in the characteristics of the variables used.

The reality of the upward trend of summer temperatures is of no particular relevance to the problem of eliminating the effect of trend factors. It is of primary importance, however, in connection with the proper measurement of the effect of the temperature factor. A detailed study of the methods employed in the construction of the temperature index failed to reveal how the trend in the index could be an artifact of the procedure employed in its construction. Nevertheless, the possibility that it is an artifact cannot be completely ruled out of consideration. [30] Thus the question of the separate contributions of the smooth and erratic components of the temperature index must be considered. The case for temperature as a significant factor affecting demand of lemons during the summer months would be strengthened if it could be shown that each component of the temperature index makes a significant contribution.

The answer to this question is already given indirectly by the equations just cited, for in those equations both the temperature index and "time" are statistically significant. More direct evidence is obtained by separating the smooth and erratic components of the temperature variable and introducing each into the regression equation in conjunction with other variables previously employed. The smooth component of the temperature index was defined by the least squares equation $x_4' = 115.75 + 1.2402\ x_5$ where $x_5$ represents "time," and the erratic component by the algebraic residuals of the temperature observations from this trend line $(x_4 - x_4')$.[31] In the regression equations given below, $x_1$ is f.o.b. price of summer lemons, $x_2$ is the United States supply of summer lemons, $x_3$ is the index of

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[30] In this connection see appendix E in which a different temperature **index** is used as an independent variable.

[31] A parabolic regression of temperature on time would have probably described the smooth component of the temperature index more fully. However, the linear trend is an excellent approximation to the smooth component of the index.

nonagricultural income payments, $x_5 = \frac{1}{1.2402}(x_4' - 115.75)$ is the adjusted linear component of the temperature index and z its erratic component. A comparison of the coefficients of $x_5$ and z with their standard errors (given in parentheses) reveals that both coefficients are significant.

$$x_1' = C_1 - \underset{(0.0030)}{0.0209}\, x_2 + \underset{(0.0073)}{0.0451}\, x_3 + \underset{(0.0131)}{0.0374}\, x_5 + \underset{(0.0050)}{0.0278}\, z$$

$$x_2' = C_2 - \underset{(5.2945)}{36.3057}\, x_1 + \underset{(0.2455)}{2.0012}\, x_3 + \underset{(0.3687)}{2.2011}\, x_5 + \underset{(0.2190)}{1.1358}\, z$$

It is likely that growth of population is a major trend influence; hence by using per-capita data the effect of at least this trend factor may to some extent be given implicit consideration. Two new variables, per-capita United States supply of summer lemons and per-capita nonagricultural income, were used, replacing United States supply and nonagricultural income, respectively. The net regression coefficients and other pertinent statistics for the analysis of the per-capita data are given in the third and fourth row of table 3 (equations 3s and 4s). The net regression lines and scatters of residuals derived from these equations are shown in the various panels of figures 5 and 6. Where comparison is possible the results are seen to be remarkably similar to those secured in the original analysis. The adjusted coefficients of multiple correlation differ but slightly from those previously secured. The estimates of flexibility and elasticity at the centroid are consistent with the values derived from equations 1s and 2s. The same statement applies to the annual flexibility and elasticities shown in columns 3 and 4 of table 5. The use of per-capita income has apparently given income greater relative importance in equation 3s than it had in equation 1s (see table 4). The significance of such a difference, however, is difficult to establish.

The per-capita formulation also allows us to test the hypothesis that the population factor is the only trend factor of significance in connection with summer

lemons. If this hypothesis were true, a trend factor, such as the trend component of the temperature variable, would fail to exert a significant influence in the per-capita formulation. The introduction of the trend and erratic components of the temperature variable ($x_4$) into the per-capita estimation equations replacing $x_4$ leads to the following equations (in normalized form):

$$\begin{array}{llllll} z_1' = & -1.0647\, z_2^{o} & +\ 0.9059\, z_3^{o} & +\ 0.3650\, z_5 & +\ 0.6122\, z \\ & (0.1464) & (0.1426) & (0.1461) & (0.1070) \end{array}$$

and

$$\begin{array}{llllll} z_2^{o'} = & -0.7318\, z_1 & +\ 0.8025\, z_3^{o} & +\ 0.4206\, z_5 & +\ 0.4985\, z \\ & (0.1006) & (0.0930) & (0.0949) & (0.0921) \end{array}$$

where $z_i = (x_i - \bar{x}_i)/\sigma_i$, $z_5$ is the trend component, and $z$ the erratic component of the temperature variable. The figures in parentheses are standard errors. Since for 15 degrees of freedom t at the 5 per cent level is 2.131, it is seen that the coefficient of $z_5$ in both equations is statistically significant. This result suggests that growth of population is not the only trend factor that may have shifted the demand for summer lemons upward during the period under review.

Thus far all of the equations were based on a formulation in which the dependent variable was treated as a linear function of the independent variables. A linear form in the logarithms of the variables has also been frequently employed in statistical demand studies, mainly, one supposes, because it leads to constant coefficients of elasticity and flexibility. The net regression coefficients and auxiliary constants secured when the logarithmic form was fitted to the data are given in the last two rows of table 3. Expressed on the arithmetic scale, equations 5s and 6s are as follows:

$$x_1' = 359.3\, x_2^{-2.0854}\, x_3^{1.0356}\, e^{0.0074\, x_4} \qquad (5s)$$

$$x_2' = 4.739\, x_1^{-0.3965}\, x_3^{0.4685}\, e^{0.0036\, x_4} \qquad (6s)$$

The logarithmic form fits the data about as well as the linear form (see the adjusted multiple correlation coefficients in table 3). The demand for summer lemons at the f.o.b. level is again shown to be inelastic. This is apparent from the values of the coefficients of price flexibility and demand elasticity shown for these equations in table 3. It will be noted that the values of these coefficients differ but little from the values of price flexibility and demand elasticity at the centroid, derived from the previous equations.

To test the possibility that trend factors may have a measurable influence in the logarithmic form, "time" was introduced linearly as an independent variable. The results secured were very similar to those obtained when "time" was introduced in equations 1s and 2s. The ratios of the net regression coefficients of "time" to their standard errors in both equations of the logarithmic form fell short of the t's corresponding to the 5 per cent level for 15 degrees of freedom.[32] It thus appears that also in the logarithmic form trend factors are of little significance, once the effects attributable to the other independent variables are eliminated.

Two other sets of regression equations require a brief comment. In the first set, imports of lemons are treated as a separate variable; in the second, the supply series is broken down into the quantity of lemons marketed by the California Fruit Growers Exchange, and the quantity sold by other marketing agencies. The shipment data used in these formulations are cited in table 2.

The equations, when domestic shipments of summer lemons and imports for consumption during the months May through October are used as separate variables (see equations 7s and 8s of table 6), show little improvement over the original formulations. The values of the adjusted multiple correlation coefficients are of

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[32] With the logarithm of f.o.b. price as the dependent variable, the ratio of the net regression coefficient to its standard error was less than 1. In the other equation, the t-ratio was 1.653. The t-ratio corresponding to the 5 per cent level for 15 degrees of freedom is 2.131.

[illegible]

[illegible]

lengths at the 5 per cent level is again shown to be inoperative. This is apparent from [illegible] differ but little from the values of price flexibility and demand elasticity at the [illegible]

To test the possibility that trend factors may have a substantial influence [illegible] the results secured were very similar to those obtained when "time" was introduced in equations 1a and 2a. The ratios of the net regression coefficients affecting the trend to their standard errors in both equations of the logarithmic form fell short of the t-value corresponding to the 5 per cent level for 17 degrees of freedom.[1] In these [illegible] once the effects attributable to the other independent variables are eliminated.

Two other sets of regression equations require a brief comment. In the first set, imports of lemons are treated as a separate variable; in the second, the supply series is broken down into the quantity of lemons marketed by the California Fruit [illegible] dent and independent variables are given in table 5.

[illegible] consumption during the months May through October are used as separate variables [illegible]

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[1] [illegible] the net regression coefficient to its standard error was less than 1. In the other [illegible] for 18 degrees of freedom is 2.101.

TABLE 6

Summer Lemons: Regression Coefficients and Auxiliary Constants for Additional Equations, 1922-1941
(Figures in parentheses are standard errors)

| Equation | Dependent variable | Net regression coefficients * | | | | | | Adjusted coefficient of multiple correlation | Elasticity of demand | Flexibility of price |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Constant term | F.o.b. price | Domestic shipments | Imports for consumption | Nonagricultural income | Index of temperatures | | | |
| | $F_{(x)}$ | c | $x_1$ | $x_{2d}$ | $x_{2i}$ | $x_3$ | $x_4$ | $\bar{R}$ | $\eta$ † | $\varphi$ † |
| 7s | $x_1$ | 4.0437 | | -0.0196<br>(0.0026) | -0.0172<br>(0.0049) | 0.0423<br>(0.0074) | 0.0289<br>(0.0048) | 0.9022 | | -1.5076 |
| 8s | $x_{2d}$ | 185.1003 | -40.5952<br>(5.3426) | | -1.0280<br>(0.1418) | 2.1283<br>(0.2462 | 1.3611<br>(0.2011) | 0.9788 | -0.4636 | |
| | | | | Exchange domestic shipments | Outside shipments | | | | | |
| | $F_{(x)}$ | c | $x_1$ | $x_{2e}$ | $x_{2o}$ | $x_3$ | $x_4$ | $\bar{R}$ | $\eta_e$ † | $\varphi_e$ † |
| 9s | $x_1$ | 4.1525 | | -0.0201<br>(0.0024) | -0.0188<br>(0.0046) | 0.0435<br>(0.0072) | 0.0287<br>(0.0050) | 0.8996 | | -1.6205 |
| 10s | $x_{2e}$ | 188.3385 | -40.8252<br>(4.9562) | | -1.0308<br>(0.1385) | 2.1274<br>(0.2466) | 1.3523<br>(0.2004) | 0.9772 | -0.5065 | |

* $x_1$ = Seasonal average f.o.b. price in dollars per box.

$x_{2d}$ = Domestic shipments of lemons in units of 10,000 boxes.

$x_{2i}$ = Imports of lemons for consumption in units of 10,000 boxes.

$x_{2e}$ = Domestic shipments of lemons by the California Fruit Growers Exchange in units of 10,000 boxes.

$x_{2o}$ = Domestic shipments of lemons outside California Fruit Growers Exchange plus imports for consumption, in units of 10,000 boxes.

$x_3$ = Index of nonagricultural income payments, 1935-39 = 100.

$x_4$ = Index of daily maximum temperature departures from 80° in 39 metropolitan districts, May through October.

† At the centroid.

about the same magnitude as those previously secured, and the residuals in the two different price equations (equations 1s and 7s) agree precisely in sign and closely in magnitude.[33] The coefficients of domestic shipments and imports for consumption agree closely in magnitude. The difference between them in relation to the magnitudes of their standard errors is so small as to obviate the necessity of testing its significance. Thus, for the period May through October, domestic shipments and imports of lemons for consumption are not distinguishable in their contributions toward the estimation of f.o.b. prices.

The second formulation attempts to test a similar hypothesis with regard to lemons marketed by shippers other than the California Fruit Growers Exchange. The multiple regression equations relating to this formulation are given in the last two rows of table 6 (equation 9s and 10s). In these equations, domestic shipments of lemons by the California Fruit Growers Exchange ($x_{2e}$) and shipments of lemons for fresh consumption by other marketing agencies plus imports for consumption ($x_{2o}$) replace the United States supply of summer lemons as the quantity variable. Since the difference between the coefficients of Exchange domestic shipments and outside shipments is small and not significant (see equation 9s), the hypothesis that lemons marketed by the California Fruit Growers Exchange and other lemons shipped for fresh consumption during the summer months are statistically differentiable components of the total United States supply of lemons must be rejected.[34]

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[33] The correlation between price residuals of equations 1s and 7s is .98.

[34] According to the "special theory of related demands" (see: Schultz, H. Theory and measurement of demand. 569-604p. University of Chicago Press, 1938), the negative sign of the coefficient $x_{2o}$ indicates that lemons marketed by the Exchange and lemons marketed by other shippers are competing. The equality of the coefficients suggests that lemons marketed by the two groups of shippers are perfectly competing. The other conditions on the parameters of the linear demand function discussed by Schultz cannot be tested because of lack of data on prices received by shippers outside the Exchange.

## Demand for Winter Lemons

Regression equations in which price of winter lemons was expressed as a linear function of domestic shipments of lemons, consumer income, and time were found to give a poor fit to the data. Equally unsatisfactory were the equations in which the logarithm of price was expressed as a linear function of the logarithms of shipments, income, and time. A study of the residuals derived from these equations revealed that the fit could not be improved by any reasonable modification of the form of the net regression functions. Apparently systematic factors, in addition to those considered above, have affected the demand for lemons during the winter months.

References to the prevalence of colds and influenza as a variable in accounting for the upward shift of demand for winter lemons are not infrequently found in citrus trade publications. Hot lemonade is probably one of the common home remedies for colds, a use of lemons which has received extensive mention in the advertising campaigns of the California Fruit Growers Exchange. Accordingly, it appeared worth while to introduce a measure of this factor into the regression equations. Since statistics on the incidence of colds are not available, only an index of the incidence of influenza could be constructed (see table 25, appendix A). This index was introduced linearly into the regression equations, and also some non-linear transformations of this variable to both algebraic and transcendental functions were used. It appeared, however, that no reasonable function of this index would be statistically significant.

First differences in annual production of lemons and first differences in Exchange lemon picks and Exchange November 1 storage were considered as possible independent variables, but their contribution did not prove significant. Other variables used in the regression equations, along with price and supply, were storage rates of lemons and various combinations of data pertaining to storage, picks, and shipments during the winter months. However, these variables also proved

[illegible]

[illegible] were found to give a poor fit to the data. Equally unsatisfactory were the equations in which [illegible] the fit could not be improved in any reasonable way. [illegible]

[illegible]

Since statistics on the incidence of collisions were not available, only an index of the incidence of influenza could be constructed (see table 20, appendix ). This index was introduced linearly into the regression equations, and also some non-linear transformations of it, both algebraic and transcendental functions were used. It appeared, however, that no reasonable function of this index would be statistically significant.

[illegible]

to be of little significance in the analysis. These unsatisfactory results may be due to the fact that the unit of time employed is too long a period in which to consider relations among picks, average storage rates, and shipments because of too extensive double counting. In a long enough period, the same lemon may be counted in picks, storage, and shipments as it passes through each of these stages on the way to final consumption.

The failure of the influenza index to improve the fit of the regression equations may be due to poor reporting of influenza case rates, but the possibility must be considered that even adequate data on incidence of influenza may not provide a measure which would prove to be statistically significant. Apparently the attack rate of influenza is not related to that of common colds.[35] Thus, while the incidence rate of influenza may itself be related to consumption of lemons, because of the relatively small frequencies involved the net effect of this factor may not be statistically measurable.

In searching about for a variable which could take the place of an index of incidence of colds, it occurred to the writers that severity of winter climate may be related to incidence of colds and consequently to consumption of lemons during the winter months. Some evidence may be cited in support of this conjecture, particularly with reference to temperature.[36] To test this conjecture statistically, an index of average temperatures for the months December, January, and

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[35] Frost, W. H. and M. Gover. Incidence and time distribution of common colds in several groups kept under continuous observation. Pub. Health Rep. 47:1815. September 2, 1932. These writers found no relation between incidence of colds and influenza in the groups under observation.

[36] Gover, M., L. J. Reed, and S. D. Collins. Time distribution of common colds and its relation to corresponding weather conditions. Pub. Health Rep. 49:811-824. July 13, 1934. In this study deviations of the weekly incidence of respiratory attack during an eighteen-month period among students in various universities in the United States were correlated with deviations of weather conditions from mean or normal. A weak but consistent inverse relation was observed between weekly departures from the norm of the respiratory attack rate and deviations from mean temperature. Other weather conditions such as hours of sunshine, wind velocity, precipitation, etc., did not show a consistent association with incidence rate of colds.

[illegible]

[illegible]

[illegible]

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[illegible]

[illegible]

February was constructed and introduced as an added variable into the regression equations. This variable proved to be statistically significant.

Before going on to the discussion of the regression equations, a point of procedure must be emphasized. The period considered is that beginning with the season 1921-22 and ending with the season 1940-41, but one season is omitted, namely 1936-37. This omission requires somewhat extensive discussion, for with only twenty observations at our disposal, the rejection of one season represents a loss of 5 per cent of the total information.

In January 1937 severe frosts occurred in southern California causing presumably extensive damage to the lemon crop. Successive forecasts of the 1936-37 lemon crop by the California Cooperative Crop Reporting Service provide a quantitative expression of current judgment concerning the extensiveness of the damage. The forecast of the crop as of January 1, 1937, just prior to the freeze, was 8,316,000 boxes. The forecast as of February 1, just after the freeze, was about 2,500,000 boxes less, namely 5,832,000 boxes. The forecasts of the volume of crop on March 1 and April 1 were of about the same magnitude as on February 1.[37] With the prospects of an extremely short crop facing the trade, the movement of lemons was brisk and the prices received, relative to the quantity moved, were quite high.[38] In point of fact, however, the frost damage to the lemon crop was not as extensive as was believed. The final production figures for 1936-37 were 7,579,000 boxes or almost 2,000,000 boxes above the February, March, and April forecasts.[39]

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[37] California Cooperative Crop Reporting Service. California Citrus Fruit Report as of January 1, 1937; February 1, 1937; March 1, 1937; April 1, 1937. Sacramento, California. (Mimeo.)

[38] See: California Fruit Growers Exchange. Annual report of the general manager for the year ended October 31, 1937.

[39] California Cooperative Crop Reporting Service. California citrus crops production and utilization estimates, 1909-10 to 1937-38. Sacramento, California. September 15, 1939.

[illegible]

[illegible] the season is omitted, namely 1936-37. This omission requires somewhat extensive discussion, for with only twenty observations at our disposal, the rejection of one season represents a loss of 5 per cent of the total information.

In January 1937 severe frosts occurred in southern California causing presumably extensive damage to the lemon crop. Successive forecasts of the 1936-37 lemon crop by the California Cooperative Crop Reporting Service provide a quantitative expression of current judgment concerning the extensiveness of the disaster. The forecast of the crop as of January 1, 1937, just prior to the freeze, was 9,215,000 boxes. The forecast as of February 1, just after the freeze, was about 2,300,000 boxes less, namely 6,852,000 boxes. The forecasts of the volume of crop on March 1 and April 1 were of about the same magnitude as on February 1. [1] With the prospects of an extremely short crop facing the trade, the movement of lemons was brisk and the prices received, relative to the quantity moved, were quite high. [2] In point of fact, however, the frost damage to the lemon crop was not as extensive as was believed. The final production figures for 1936-37 were 7,273,000 [illegible]

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[1] California Cooperative Crop Reporting Service. California Fruit Crop Forecasts as of January 1, 1937; February 1, 1937; March 1, 1937; April 1, 1937. Sacramento, California. (Mimeo.)

[2] [illegible] for the year ended October 31, 1937.

[3] [illegible] tion and utilization estimates, 1920-21 to 1937-38. Sacramento, California, [illegible]

It is believed that this combination of factors was unique in the twenty-year period under review.

As an alternative to omitting 1936-37, the domestic shipment figure for that season was reduced to the level of expectations based on the just quoted forecasts of the lemon crop by the California Crop Reporting Service. The use of the adjusted shipment figure gave results almost identical with those secured when the season was omitted. Because of the somewhat arbitrary character of the adjustment, however, it was deemed preferable to omit the season. 40/

In table 8 are given the net regression coefficients and auxiliary constants corresponding to six equations, each based on nineteen observations. The series used are given in table 7. The equations are of the same form as those calculated for summer lemons. 41/ It will be noted that the adjusted multiple correlation coefficients are of about the same magnitude as those secured for analogous summer regression equations; that the linear form, per-capita formulation, and the logarithmic form fit the data equally well; that the estimation equations with shipments as the dependent variable fit the data better than the regression equation with f.o.b. price as the dependent variable; that all of the net regression coefficients are apparently significant; and that the demand for winter lemons

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40/ The net regression coefficients and auxiliary constants when all of the observations were used and when the 1936-37 shipment observation was adjusted are given in table 30, appendix D.

41/ It should be pointed out that in calculating per-capita domestic shipments and per-capita nonagricultural income, population figures as of July 1 were employed. In this analysis it would have been formally more correct to have used population figures adjusted to January 1 of each year. In view of the fallibility of the annual population estimates, especially of the estimates of farm population, such an adjustment was not deemed worth while. Later calculations indicated that the use of population figures interpolated to January 1 of each year would have had the following effects on the two per-capita series -- 9 per-capita domestic shipment figures would each have changed by 0.01 and 5 values of the index of per-capita nonagricultural income would have each changed by 1 point. Such changes could have but an entirely negligible effect on the magnitudes of the various statistical constants calculated in the winter lemon analysis.

## TABLE 7

### Winter Lemons: Basic Series Used in the Demand Analysis, 1921-22 to 1940-41

| Year November-April | F.o.b. price $x_1$ | Domestic shipments $x_2$ | Per capita domestic shipments $x_2^o$ | C.F.G.E. domestic shipments $x_{2e}$ | Outside domestic shipments $x_{2o}$ | Index of nonagricultural income * $x_3$ | Per capita nonagricultural income $x_3^o$ | Index of temperatures † $x_4$ |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | dollars | 1,000 boxes | pounds | 1,000 boxes | 1,000 boxes | per cent | per cent | per cent |
| 1921-22 | 3.48 | 1,641 | 1.14 | 1,423 | 218 | 71 | 71 | 81 |
| 1922-23 | 4.20 | 1,308 | 0.89 | 1,226 | 82 | 83 | 81 | 78 |
| 1923-24 | 2.38 | 1,911 | 1.28 | 1,754 | 157 | 92 | 88 | 85 |
| 1924-25 | 3.87 | 1,648 | 1.09 | 1,491 | 157 | 93 | 87 | 82 |
| 1925-26 | 3.33 | 1,750 | 1.14 | 1,623 | 127 | 100 | 91 | 80 |
| 1926-27 | 2.73 | 1,954 | 1.26 | 1,570 | 384 | 102 | 91 | 82 |
| 1927-28 | 4.81 | 1,517 | 0.96 | 1,393 | 124 | 102 | 89 | 84 |
| 1928-29 | 3.58 | 2,146 | 1.34 | 1,881 | 265 | 106 | 91 | 81 |
| 1929-30 | 4.94 | 1,558 | 0.96 | 1,410 | 148 | 105 | 89 | 86 |
| 1930-31 | 3.09 | 2,008 | 1.23 | 1,713 | 295 | 91 | 76 | 87 |
| 1931-32 | 2.49 | 1,984 | 1.21 | 1,615 | 369 | 75 | 63 | 100 |
| 1932-33 | 3.09 | 1,761 | 1.07 | 1,556 | 205 | 61 | 51 | 91 |
| 1933-34 | 3.20 | 2,073 | 1.25 | 1,820 | 253 | 69 | 57 | 76 |
| 1934-35 | 2.18 | 2,609 | 1.56 | 2,077 | 532 | 74 | 61 | 79 |
| 1935-36 | 3.72 | 2,339 | 1.39 | 2,174 | 165 | 82 | 67 | 67 |
| 1936-37 | 3.79 | 2,559 | 1.30 | 2,393 | 166 | 93 | 75 | 90 |
| 1937-38 | 3.50 | 2,283 | 1.34 | 2,078 | 205 | 88 | 70 | 84 |
| 1938-39 | 2.56 | 2,491 | 1.45 | 2,143 | 348 | 90 | 71 | 87 |
| 1939-40 | 2.99 | 2,746 | 1.58 | 2,345 | 401 | 97 | 76 | 77 |
| 1940-41 | 2.42 | 3,013 | 1.72 | 2,459 | 554 | 109 | 85 | 83 |
| $\bar{x}$ ≠ | 3.293 | 2,038.9 | 1.256 | 1,776.4 | 262.6 | 88.9 | 76.6 | 82.6 |
| $\sigma$ ≠ | 0.762 | 440.0 | 0.216 | 341.2 | 132.8 | 13.6 | 12.4 | 6.5 |

* 1925-1929 = 100.
† 1931-32 = 100.
≠ Excluding 1936-37.

Sources of data: Col. 1: Table 13.
Cols. 2 and 3: Table 17.
Cols. 4 and 5: Table 20.
Cols. 6 and 7: Table 22.
Col. 8: Table 23.

TABLE 8

Winter Lemons: Regression Coefficients and Auxiliary Constants
1921-22 to 1940-41 (1936-37 excluded)
(Figures in parentheses are standard errors)

| Equation | Dependent variable | Net regression coefficients * | | | | | | Adjusted coefficient of multiple correlation | Elasticity of demand | Flexibility of price |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Constant term | F.o.b. price | Domestic shipments | Nonagricultural income | Index of temperatures | Time | | | |
| | $F_{(x)}$ | c | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $\bar{R}$ | $\eta$ † | $\varphi$ † |
| 1w | $x_1$ | 10.9472 | | -0.0028<br>(0.0004) | 0.0225<br>(0.0059) | -0.0484<br>(0.0124) | 0.0636<br>(0.0132) | 0.9022 | | -1.7044 |
| 2w | $x_2$ | 3,690.0778 | -294.9264<br>(37.9669) | | 7.3125<br>(1.9295) | -15.9275<br>(4.0358) | 24.8053<br>(2.3908) | 0.9697 | -0.4764 | |
| | | | | Per capita domestic shipments | Per capita nonagricultural income | | | | | |
| | $F_{(x)}$ | c | $x_1$ | $x_2^o$ | $x_3^o$ | $x_4$ | $x_5$ | $\bar{R}$ | $\eta$ † | $\varphi$ † |
| 3w | $x_1$ | 10.9687 | | -4.4674<br>(0.5679) | 0.0245<br>(0.0071) | -0.0474<br>(0.0124) | 0.0479<br>(0.0113) | 0.9021 | | -1.7038 |
| 4w | $x_2^o$ | 2.2768 | -0.1825<br>(0.0232) | | 0.0050<br>(0.0014) | -0.0096<br>(0.0025) | 0.0115<br>(0.0016) | 0.9514 | -0.4786 | |
| | $F_{(x)}$ | c | Log $x_1$ | Log $x_2$ | Log $x_3$ | Log $x_4$ | $x_5$ ‡ | $\bar{R}$ | $\eta$ | $\varphi$ |
| 5w | Log $x_1$ | 5.4798 | | -1.5816<br>(0.2191) | (0.4610<br>(0.1544) | -1.1632<br>(0.3182) | 0.0169<br>(0.0040) | 0.8898 | | -1.5816 |
| 6w | Log $x_2$ | 3.2845 | -0.4984<br>(0.0690) | | 0.2566<br>(0.0872) | -0.6412<br>(0.1816) | 0.0117<br>(0.0013) | 0.9623 | -0.4984 | |

(Footnotes on next page)

(Table 8 continued)

* $x_1$ = Seasonal average f.o.b. prices in dollars per box.

$x_2$ = Domestic shipments of California and Arizona lemons in units of 1,000 boxes.

$x_2^o$ = Per capita domestic shipments of California and Arizona lemons in pounds.

$x_3$ = Index of nonagricultural income payments, 1924-25 to 1928-29 = 100.

$x_3^o$ = Per capita index of nonagricultural income payments in per cent.

$x_4$ = Index of mean temperatures in December, January, and February in 32 metropolitan districts, 1931-32 = 100.

$x_5$ = Time in units of half-years, origin half-way between 1930-31 and 1931-32.

† At the centroid.

‡ In natural logarithms.

measured at the centroid is consistently inelastic in all formulations. Attention is also drawn to the annual values of price flexibility and demand elasticity based on equations 1w, 2w, 3w, and 4w (see table 9). For three of the nineteen seasons under consideration -- namely, 1922-23, 1927-28, and 1929-30 -- the values of the coefficient of price flexibility indicate that the demand for winter lemons was elastic. Otherwise, the remaining entries confirm the presumption that an inelastic demand for winter lemons faced handlers of lemons during the period under review.[42]

The net regression lines and scatters of residuals derived from the equations cited in table 8 are shown in the various panels of figures 9, 10, 11, 12, 13, and 14, appendix C. In no case is it apparent that a modification of the form of net regressions would result in a significant improvement of fit. The results of the tests of randomness of residuals are summarized in table 29, appendix B. It is evident that the hypothesis of randomness of residuals with respect to time cannot be rejected on the basis of these tests.

An examination of the scatters of residuals about the net regression of price and of shipments on temperature (see panel C of figs. 9 to 14, appendix C) might lead to the conclusion that the temperature variable would not contribute significantly, were it not for the close fit of the observations for 1931-32 and 1935-36. To test this suggestion, the seasons 1931-32 and 1935-36 were omitted and two equations, one with f.o.b. price and the other with per-capita shipments as the dependent variable, were fitted to the remaining seventeen observations.

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[42] The unbiased estimates of the variance of the best linear unbiased estimates of $x_1$ and $x_2$ (equations 1w and 2w) are,

$$\mu_{f_1}^2 = 0.0060 + 0.0243z_2^2 + 0.0064z_3^2 + 0.0065z_4^2 + 0.0233z_5^2 - 0.0055z_2z_3 + $$
$$+0.0062z_2z_4 - 0.0409z_2z_5 + 0.0003z_3z_4 + 0.0093z_3z_5 - 0.0048z_4z_5$$

and

$$\mu_{f_2}^2 = 642.74 + 836.74z_1^2 + 688.13z_3^2 + 684.43z_4^2 + 761.76z_5^2 - 370.12z_1z_3 + $$
$$+347.73z_1z_4 + 627.91z_1z_5 + 29.59z_3z_4 - 149.24z_3z_5 + 184.91z_4z_5,$$

where $z_i = \frac{1}{\sigma_i}(x_i - \bar{x}_i)$.

## TABLE 9

Winter Lemons: Calculated Coefficients of Price Flexibility and Demand Elasticity, 1921-22 to 1940-41. (1936-37 excluded)

| Year November-April | Price flexibility $\varphi$ | Demand elasticity $\eta$ | Per capita formulation | |
|---|---|---|---|---|
| | | | Price flexibility $\varphi$ | Demand elasticity $\eta$ |
| 1921-22 | -1.5619 | -0.7220 | -1.7760 | -0.6370 |
| 1922-23 | -0.8276 | -0.8884 | -0.8900 | -0.7923 |
| 1923-24 | -1.9620 | -0.3627 | -2.1491 | -0.3367 |
| 1924-25 | -1.2260 | -0.7132 | -1.3079 | -0.6632 |
| 1925-26 | -1.2675 | -0.5190 | -1.3444 | -0.4958 |
| 1926-27 | -1.6230 | -0.3831 | -1.7303 | -0.3721 |
| 1927-28 | -0.9183 | -0.9415 | -0.9435 | -0.9209 |
| 1928-29 | -1.8584 | -0.5292 | -1.9095 | -0.5271 |
| 1929-30 | -0.9204 | -0.9359 | -0.9238 | -0.9427 |
| 1930-31 | -1.7353 | -0.4481 | -1.7352 | -0.4538 |
| 1931-32 | -2.2855 | -0.3791 | -2.2358 | -0.3833 |
| 1932-33 | -1.4905 | -0.4926 | -1.4611 | -0.5009 |
| 1933-34 | -1.6654 | -0.4360 | -1.6325 | -0.4483 |
| 1934-35 | -3.5114 | -0.2568 | -3.3389 | -0.2647 |
| 1935-36 | -1.7513 | -0.4671 | -1.6976 | -0.4884 |
| 1936-37 | | | | |
| 1937-38 | -1.8502 | -0.4516 | -1.7916 | -0.4810 |
| 1938-39 | -2.4053 | -0.2927 | -2.2904 | -0.3117 |
| 1939-40 | -2.5908 | -0.3251 | -2.4013 | -0.3488 |
| 1940-41 | -3.6239 | -0.2442 | -3.2754 | -0.2632 |

Source of data:

Calculated from equations 1w, 2w, 3w, and 4w respectively for the values of the independent variables which prevailed in the various years.

The two equations (in standard form) are given below (the figures in parentheses are standard errors of the $\beta$ - coefficients). The adjusted coefficients of multiple correlation are fairly high, 0.8902 for the first equation and 0.9494 for the second equation. The t-ratio for the coefficient $\beta_{14}$ is 1.979. Since the set of admissible alternatives specifies negative values of $\beta_{14}$ we need to consider only one tail of the t-distribution. For 12 degrees freedom $t_{.05}$ is 1.782 and thus the null hypothesis can be rejected. The t-ratio for the coefficient $\beta_{24}$ is 2.455. These results tend to strengthen the presumption that the temperature factor is a significant variable affecting the demand for lemons during the winter months.

$$\begin{array}{lllll} z_1' = & -1.3023z_2 & + 0.4029z_3 & - 0.2412z_4 & + 0.7415z_5 \\ & (0.1844) & (0.1282) & (0.1219) & (0.1960) \end{array}$$

$$\begin{array}{lllll} z_2' = & -0.6189z_1 & + 0.2794z_3 & - 0.1939z_4 & + 0.6177z_5 \\ & (0.0876) & (0.0879) & (0.0790) & (0.0907) \end{array}$$

The coefficients of separate determination for all of the regression equations summarized in table 8 are given in table 10. It will be noted that the contribution of winter temperatures to the variance of the dependent variable is of about the same magnitude as that of income in all of the formulations thus far considered. Each of these variables contributes less than 10 per cent to the variance of the dependent variable. With price as the dependent variable, the contribution of the trend factors is somewhat larger, between 15 and 20 per cent, but still considerably smaller than the contribution of the quantity variable. However, in the equations with domestic shipments as the dependent variable, the trend factors are seen to "account" for a large proportion of the variance of the dependent variable. Thus in equation 2w, 55 per cent of the variance of the dependent variable is allocated to the trend factors and only 33 per cent of the variance to the price factor. It is for this reason that the per-capita formulation is of particular significance in the winter analysis, for obviously it is necessary

## TABLE 10

### Winter Lemons: Coefficients of Separate Determination

| Equation | Dependent variable | F.o.b. price $x_1$ | Domestic shipments $x_2$ | Per capita domestic shipments $x_2^o$ | Index of nonagricultural income $x_3$ | Per capita nonagricultural income $x_3^o$ | Index of temperatures $x_4$ | Time $x_5$ |
|---|---|---|---|---|---|---|---|---|
| | | Per cent | | | | | | |
| 1w | $x_1$ | | 56.4 | | 5.2 | | 4.8 | 19.3 |
| 2w | $x_2$ | 33.0 | | | 3.0 | | 4.1 | 55.3 |
| 3w | $x_1$ | | | 55.6 | | 8.4 | 5.2 | 16.3 |
| 4w | $x_2^o$ | 41.5 | | | | 4.4 | 5.4 | 41.3 |
| 5w | Log $x_1$ | | 56.7 | | 3.8 | | 5.4 | 18.0 |
| 6w | Log $x_2$ | 35.3 | | | 2.1 | | 3.9 | 53.1 |

Source of data:

Based on equations 1w through 6w given in table 8. Coefficients based on equations 1w, 3w, 4w, and 5w adjusted to remove negative signs.

to account more explicitly for the multitude of influences that are represented by time. However, the introduction of the population factor, while reducing the contribution of "time," still leaves it of considerable importance. Thus in equation 4w, roughly 41 per cent of the shipment variance is allocated to the trend factors. The major importance of the time variable in the shipment equations is an undesirable feature of these equations and one which should induce considerable caution in their use.

In all of the equations thus far considered, the quantity variable was represented by domestic shipments of lemons during the months November through April of each year. In the summer analysis imports were shown to be a homogeneous part of the total supply of lemons during the months May through October. Such, apparently, is not the case during the winter months. The use of United States supply of lemons during the winter months -- that is, of domestic shipments plus imports -- as the quantity variable reduces the adjusted multiple correlation coefficient from 0.9022 to 0.5144 with price as the dependent variable and from 0.9697 to 0.8656 with United States supply as the dependent variable. It is not satisfactory, either, to include imports separately as an independent variable, for then imports add little to the fit of either the price or the shipment equations. This analysis has found no empirical grounds for including imports explicitly or implicitly in the equations for winter lemons.

The lack of relevance of the import variable during the winter months is difficult to explain, especially in view of the fact that the relative magnitudes of imports for consumption during the two seasons were quite similar. It is possible that lemons imported during the winter months were intended primarily for consumption during the summer months. The fact that heavy imports of lemons have usually occurred in February, March, and April lends some support to this conjecture.[43/]

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[43/] However, domestic shipments of lemons also exhibit practically the same pattern. For the ten-year period 1921-22 through 1930-31, imports of lemons for consumption during the months November, December, and January constituted 19.4 per cent of the California Fruit Growers Exchange movement of lemons into fresh consumption. For the months February, March, and April this proportion rose only to 21.3 per cent.

to account more explicitly for the multitude of influences that are represented by [illegible] the [illegible] of "time" until leaves it of considerable importance. Thus in equation [illegible] roughly 41 per cent of the shipment variance is allocated to the trend factors. The major importance of the time variable in the shipment equations is an undesirable feature of these equations and one which should induce considerable caution in their use.

In all of the equations thus far considered, the quantity variable was represented [illegible] of each year. In the summer analysis imports were shown to be a homogeneous part of the total supply of lemons during the months May through October. Such, apparently, is not the case during the winter months. The use of United States supply of lemons during the winter months -- that is, of domestic shipments plus imports -- as the quantity variable reduces the adjusted multiple correlation coefficient from 0.9022 to 0.5142 with f.o.b. prices as the dependent variable and from 0.9897 to 0.9865 [illegible] to include imports separately as an independent variable, for then imports add little to the fit of either the price or the shipment equations. This analysis has found no empirical grounds for including imports explicitly or implicitly in the equations [illegible]

The lack of relevance of the import variable during the winter months is difficult to explain, especially in view of the fact that the relative magnitudes [illegible] during the winter months [illegible] occurred in February, March, and April lends some support to this conjecture. [illegible]

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[illegible]

It is also possible that due to sudden and large shifts of demand induced by weather factors, the product differentiation which obtains during the winter is much weakened during the summer months. While the first possibility appears, off-hand, to be more plausible than the second, neither has direct evidence which could be cited in its support.

As was the case in the analysis of data on summer lemons, the replacement of domestic shipments by two quantity variables, one consisting of domestic shipments by the California Fruit Growers Exchange and the other of domestic shipments by other marketing agencies, leads to the conclusion that such a breakdown of the quantity variable has little effect. Below is given the price equation in which Exchange domestic shipments ($x_{2e}$) and domestic shipments of shippers outside of the Exchange ($x_{2o}$) are used as two independent variables. The other variables in the equation are f.o.b. prices ($x_1$), index of nonagricultural income ($x_3$), index of temperatures in December, January, and February ($x_4$), and "time" ($x_5$). The figures in parentheses are standard errors of the partial regression coefficients. While the adjusted multiple correlation coefficient is somewhat lower for this equation than for equation 1w (0.8502 as against 0.9032), the coefficients of the two quantity series are almost identical in magnitude.

$$x_1' = 3.2926 - \underset{(0.0006)}{0.0028}x_{2e} - \underset{(0.0010)}{0.0027}x_{2o} + \underset{(0.0062)}{0.0226}x_3 - \underset{(0.0155)}{0.0492}x_4 + \underset{(0.0151)}{0.0642}x_5$$

## Allocation of Shipments

In this section we shall confine ourselves to a brief consideration of two types of allocation of shipments over time. In the first class are included allocations designed to maximize returns to the industry; the second is comprised of allocations designed to maximize shipments or minimize prices for fixed "net" returns to the industry.

The basic interval of time for which most marketing decisions are made in the lemon industry is much shorter than the six-month period on which the analyses described in the preceding section were based. However, if the results of these analyses are to be at all useful in connection with the problem of allocation, a time interval shorter than six months cannot be employed. Thus the allocation of shipments that will be considered is that between the two periods November through April and May through October of each marketing year. The discussion to follow is pertinent to decisions concerning shipments for other time intervals only in so far as such decisions affect the total quantity shipped during each of the two six-month periods.

We shall begin by determining the allocation required to maximize f.o.b. returns. In this simplified case all costs to growers are disregarded. Furthermore, neither returns from diversion of lemons to processing nor the long-run effects of the allocation are considered. Subsequently we shall take into account some of the costs and the additional revenue from processed fruit received by the growers. The long-run effects of the allocations discussed in this section, however, cannot be determined on the basis of the information at present available.

For a given marketing year let the price-quantity relation in each of the two subperiods be,

$$x_1 = a + a_2 x_2$$

$$y_1 = b + b_2 y_2$$

where $x_1$ is the f.o.b. price per box and $x_2$ domestic shipments for the six-month

period November through April, and where $y_1$ and $y_2$ denote respectively f.o.b. prices and domestic shipments for the period May through October. The f.o.b. returns for a given year are given by:

$$R = ax_2 + by_2 + a_2x_2^2 + b_2y_2^2$$

The values of $x_2$ and $y_2$ maximizing R ("optimum shipments") are easily shown to be

$$x_2^o = \frac{-a}{2a_2} \qquad y_2^o = \frac{-b}{2b_2} \qquad \text{(A)}$$

If the constraint $x_2 + y_2 = q$, where q is a fixed value, is introduced, shipments maximizing f.o.b. returns are given by the expressions:

$$x_2' = \frac{b - a + 2b_2q}{2(a_2 + b_2)} \qquad y_2' = q - x_2' \qquad \text{(B)}$$

The shipments of winter and summer lemons maximizing f.o.b. returns with and without constraint for the years 1921-22 to 1940-41 are found in table 11. One set of these figures is based on equations 7s and 1w -- the other, on equations 8s and 2w solved for f.o.b. price. [44] To determine the constrained optimum shipments, f.o.b. returns were maximized under the condition that the sum of optimum shipments of winter and summer lemons for each marketing year equal the actual quantity shipped during the year. In figure 2 the series of optimum shipments are represented graphically together with the actual domestic shipments of winter and summer lemons. The shading of the area between estimates of optimum shipments, derived for winter lemons from equations 1w and 2w and for summer lemons from equations 7s and 8s, is intended to suggest the existence of a zone of uncertainty for these estimates in

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[44] These equations were chosen because they contain explicitly the relevant variable to which allocation can be applied, namely, domestic shipments.

## TABLE 11

Allocation of November-April and May-October Lemon Shipments to Maximize F.O.B. Returns for an Undetermined and for a Fixed Volume of Annual Shipments, 1921-22 to 1940-41

| Year | Domestic shipments | | Unrestricted optimum allocation | | | | Restricted optimum allocation | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Equations 1w and 7s | | Equations 2w and 8s | | Equations 1w and 7s | | Equations 2w and 8s | |
| | November-April $x_2$ | May-October $y_2$ | November-April $x_2^o$ | May-October $y_2^o$ | November-April $x_2^o$ | May October $y_2^o$ | November-April $x_2'$ | May-October $y_2'$ | November-April $x_2'$ | May-October $y_2'$ |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | 10,000 boxes | | | | | | | | | |
| 1921-22 | 164 | 235 | 135 | 231 | 122 | 206 | 148 | 251 | 152 | 247 |
| 1922-23 | 131 | 202 | 144 | 231 | 132 | 205 | 127 | 206 | 130 | 203 |
| 1923-24 | 191 | 322 | 144 | 251 | 132 | 231 | 193 | 320 | 195 | 318 |
| 1924-25 | 165 | 289 | 150 | 263 | 137 | 235 | 167 | 287 | 171 | 282 |
| 1925-26 | 175 | 328 | 157 | 258 | 144 | 235 | 194 | 310 | 196 | 307 |
| 1926-27 | 195 | 289 | 158 | 257 | 145 | 235 | 187 | 298 | 189 | 295 |
| 1927-28 | 152 | 303 | 158 | 277 | 146 | 256 | 166 | 289 | 168 | 286 |
| 1928-29 | 215 | 322 | 165 | 299 | 153 | 278 | 195 | 342 | 197 | 340 |
| 1929-30 | 156 | 333 | 163 | 301 | 151 | 276 | 173 | 316 | 177 | 312 |
| 1930-31 | 201 | 381 | 158 | 310 | 147 | 288 | 205 | 377 | 209 | 373 |
| 1931-32 | 198 | 307 | 143 | 263 | 134 | 244 | 184 | 321 | 188 | 318 |
| 1932-33 | 176 | 347 | 147 | 277 | 138 | 257 | 188 | 335 | 192 | 331 |
| 1933-34 | 207 | 404 | 166 | 295 | 155 | 275 | 228 | 383 | 232 | 380 |
| 1934-35 | 261 | 416 | 168 | 276 | 157 | 257 | 265 | 412 | 268 | 409 |
| 1935-36 | 234 | 427 | 184 | 326 | 172 | 304 | 247 | 414 | 250 | 411 |
| 1936-37 | | | | | | | | | | |
| 1937-38 | 228 | 435 | 176 | 295 | 166 | 276 | 256 | 407 | 259 | 404 |
| 1938-39 | 249 | 470 | 176 | 322 | 167 | 302 | 268 | 451 | 272 | 447 |
| 1939-40 | 275 | 461 | 190 | 305 | 180 | 286 | 290 | 445 | 293 | 442 |
| 1940-41 | 301 | 550 | 192 | 356 | 182 | 335 | 318 | 533 | 323 | 529 |

Sources of data:

Col. 1: Col. 2 of table 7.

Col. 2: Col. 4 of table 2.

Cols. 3 and 4: Based on expressions (A), see text, applied to equations 1w of table 8 and 7s of table 6.

Cols. 5 and 6: Based on expressions (A), see text, applied to equations 2w of table 8 and 8s of table 6.

Cols. 7 and 8: Based on expressions (B), see text, with the constraint $x_2' + y_2' = x_2 + y_2$, applied to equations 1w of table 8 and 7s of table 6.

Cols. 9 and 10: Based on equations (B), see text,with the constraint $x_2' + y_2' = x_2 + y_2$, applied to equations 2w of table 8 and 8s of table 6.

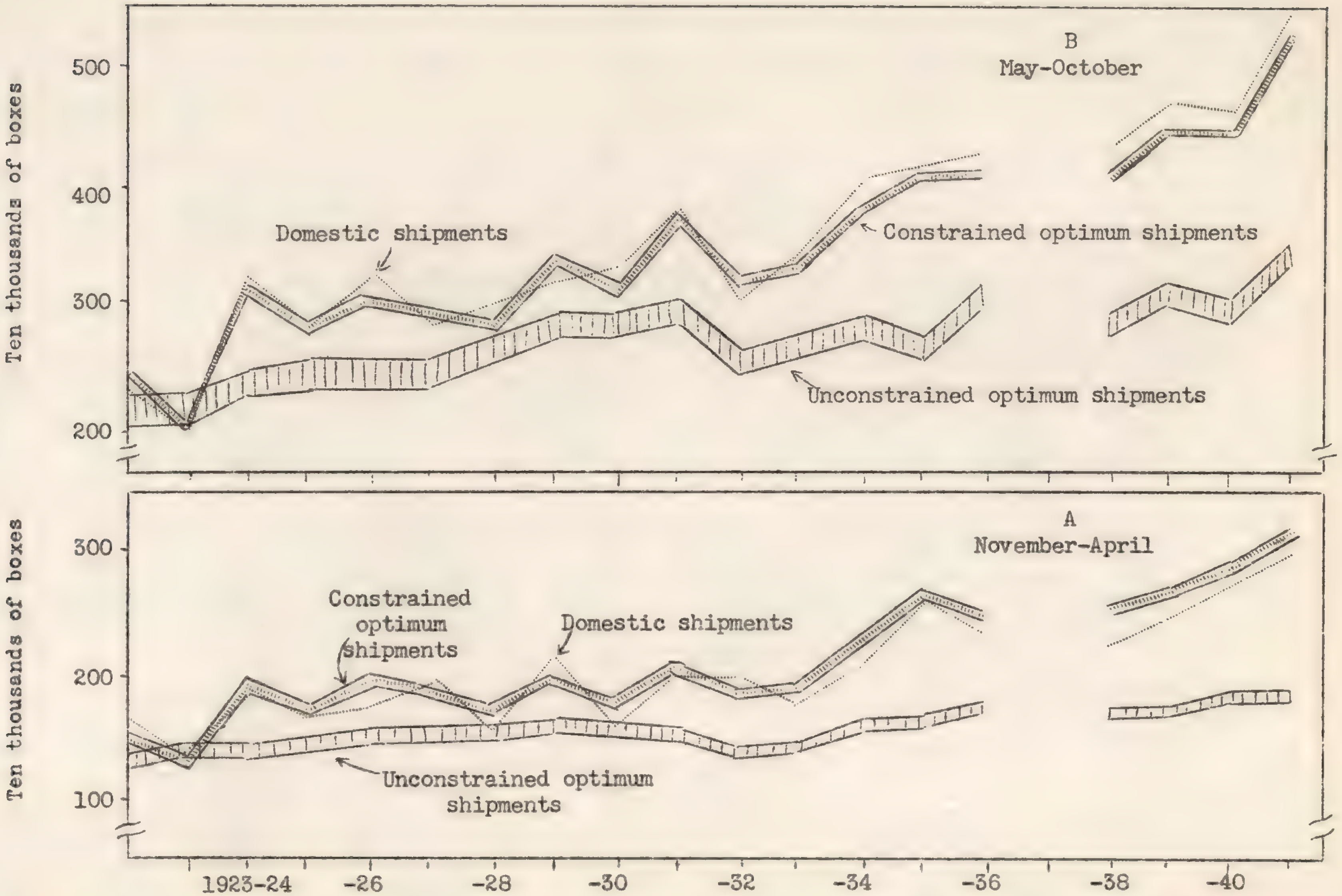
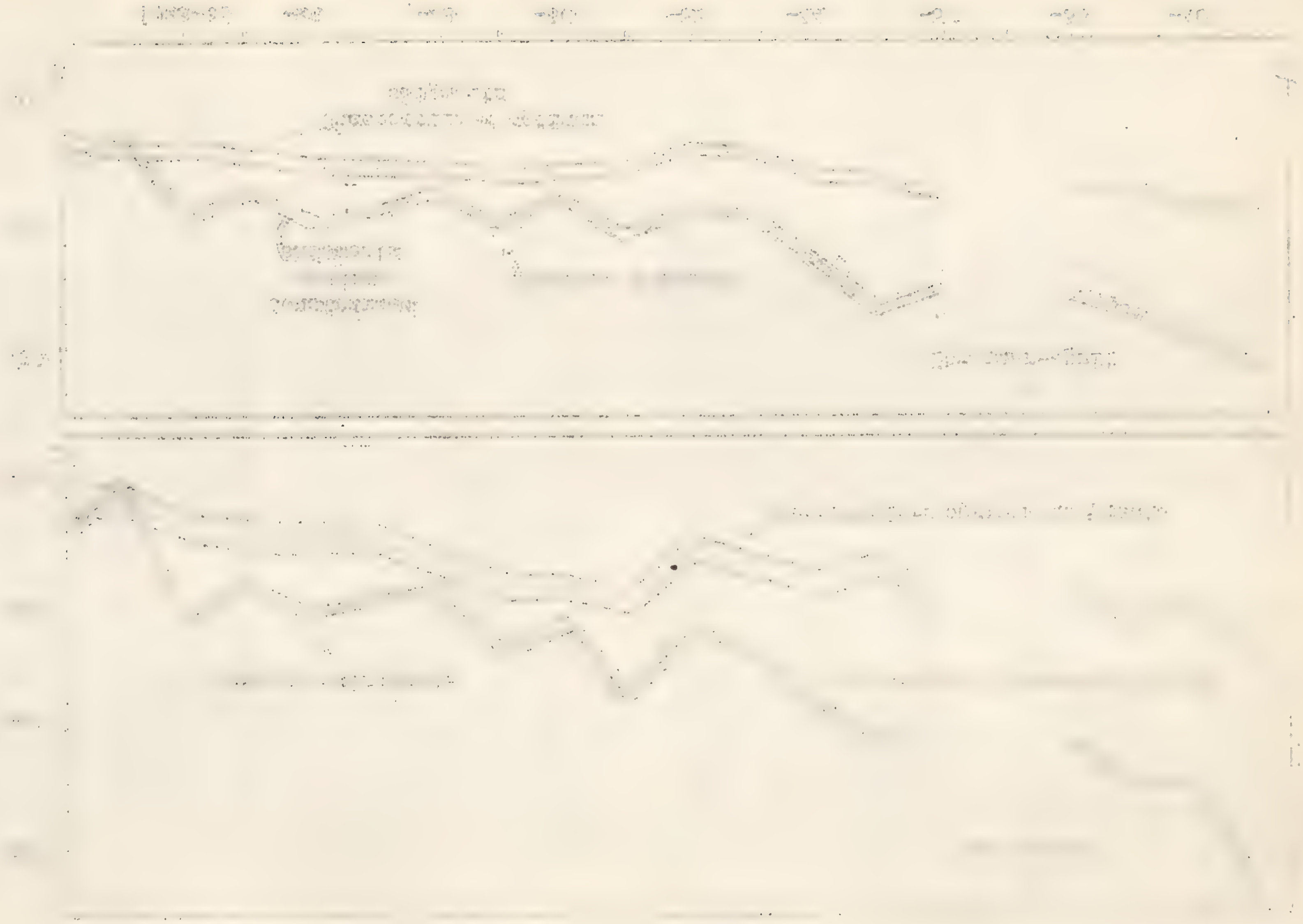


Fig. 2.-- Domestic shipments of (A) winter and (B) summer lemons and shipments maximizing f.o.b. returns, 1921-22 to 1940-41. (Data from table 11.)



addition to that implied by the standard errors of the estimates. Since equations with price as the dependent variable and equations with quantity as the dependent variable are *a priori* equally acceptable, the differences between the results secured on the basis of these equations should in some way become a part of the measure of uncertainty to accompany these calculations.[45] It is not implied, however, that the "true" optimum shipments necessarily lie within these zones.

Inspection of figure 2 leads to the following observations: (1) The optimum shipments of winter and summer lemons in the case of the unconstrained maximum are considerably smaller than the actual shipments. For summer lemons in only one season and for winter lemons in only three seasons have the actual shipments been of the same order of magnitude as the shipments maximizing f.o.b. returns. The gap between the actual and optimum shipments is markedly greater during the latter part of the period than during the earlier years. Furthermore, during the latter half of the period the differences between the actual and optimum shipments of summer lemons are larger than the differences for winter lemons. (2) The optimum shipments of winter and summer lemons in the case of the constrained maximum do not differ greatly from the actual shipments. However, beginning with 1933 the optimum shipments of summer lemons are slightly but consistently smaller than the actual shipments. For winter lemons this tendency is, obviously, in the opposite direction. Thus both sets of calculations, those for the constrained maximum and those for the unconstrained maximum, suggest that during the latter half of the period, relative to prevailing demand conditions, an overshipment of summer lemons has taken place. This conclusion is in harmony with the observation made earlier (page 2 ) concerning the downward trend of prices of summer lemons during roughly

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[45] The studies of Frisch and Koopmans are relevant in this connection: Frisch, R. Statistical confluence analysis by means of complete regression systems. Oslo. 1934; and Koopmans, T. Linear regression analysis of economic time series. Haarlem. 1937.

the same part of the period.

It may appear from the figures cited in connection with the unconstrained maximum that a drastic curtailment of shipments of summer and winter lemons in many of the years considered would have increased markedly f.o.b. returns to the industry for the period. It should be emphasized that such a conclusion is unwarranted. The formulation employed herein does not permit assessment of the long-run effects of an allocation policy. An obvious consequence of a drastic curtailment of lemon shipments is a shift on the part of consumers to substitutes. It is probable that within the range of lemon prices which have thus far prevailed, the level of prices of technically substitutable commodities has not had an important influence on the demand for lemons. However, in higher price ranges -- effectuated by markedly curtailed shipments -- substitution may become a factor of major importance.

Introduction of costs and additional revenues arising from the sale of lemons for manufacture has the effect of further decreasing optimum shipments derived for the unconstrained maximum. These new elements are introduced by maximizing for a given year "value on tree" defined as

$$V = R - (g + h)(x_2 + y_2) + (Q - x_2 - y_2) z,$$

where g represents picking and hauling costs per box, h represents the packing-house charge and selling (including advertising costs), Q the total lemon crop, and, finally, z the price "on tree" of lemons used for processing; R, as before, denotes f.o.b. returns for packed and loose fruit. The reader will note the simplifying assumption of constant average "variable" costs and the further assumption of a fixed "on tree" price of lemons diverted to manufacture. Cultural costs, interest on investment, and depreciation allowance are not included in this formulation.

The shipments maximizing V are given by

$$\begin{aligned} x_2'' &= x_2^0 + \frac{g + h + z}{2a_2} \\ y_2'' &= y_2^0 + \frac{g + h + z}{2b_2} \end{aligned} \qquad (c)$$

It is apparent from expressions (C) that shipments maximizing V will be smaller than shipments maximizing R, that is, that the demand at the "on tree" level is more inelastic than the demand for lemons at the f.o.b. level. The introduction of costs and additional revenue from processing has no effect on the magnitudes of optimum shipments derived for the constrained maximum.

The application of the remaining criterion involves the maximization of $U = x_2 + y_2$ under the condition $V = V_c$ or the minimization of $W = R\ (x_2 + y_2)^{-1}$ under the same constraint. The values of $x_2$ and $y_2$ maximizing U or minimizing W are given by:

$$\begin{aligned} x_2''' &= x_2'' + \sqrt{\frac{b_2\ (V_c - F)}{a_2\ (a_2 + b_2)}} \\ y_2''' &= y_2'' + \sqrt{\frac{a_2\ (V_c - F)}{b_2\ (a_2 + b_2)}} \end{aligned} \qquad \text{(D)}$$

where $F = Qz - a_2(x_2'')^2 - b_2(y_2'')^2$.

In table 12 are indicated the values of optimum shipments for the three years 1937-38 through 1939-40 calculated from (C) and (D). The differences between the optimum shipments maximizing "value on tree" and the shipments minimizing the annual weighted average price for a fixed "on tree" value are very large. Since the magnitude of such differences is a function of the value selected for V no significance attaches to the particular magnitudes of optimum shipments given in table 12. These are to be viewed as numerical illustrations of the expressions (C) and (D) designed to make their meaning more concrete. Of some interest, however, is the following observation. Let d be the difference between the optimum shipments calculated from expressions (C) and (D), that is $(x''' - x'')$ or $(y''' - y'')$, and let d' be the value of d for $V_c = 0$. It is easily seen that

$$\frac{d}{d'} = \sqrt{1 - \frac{V_c}{V_c'}}$$

where $V_c'$ is the maximum value of $V_c$. Thus relatively large differences between optimum shipments derived from expressions (C) and (D) are to be expected for a large range of values of V.

TABLE 12

Shipments of Summer and Winter Lemons Maximizing Value on Tree and Minimizing Average Annual F.O.B. Price for Fixed Value on Tree

| Year | Annual production Q | Costs f.o.b. packing house less cultural costs g + h | Price on tree for manufacture z | Shipments maximizing value on tree | | Value on tree V | Shipments minimizing prices for fixed value on tree | |
|---|---|---|---|---|---|---|---|---|
| | | | | November-April $x_2''$ | May-October $y_2''$ | | November-April $x_2'''$ | May-October $y_2'''$ |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | 10,000 boxes | dollars per box | dollars per box | 10,000 boxes | 10,000 boxes | 1,000 dollars | 10,000 boxes | 10,000 boxes |
| 1937-38 | 930 | 1.32 | 0.11 | 150 | 259 | 12,518 | 258 | 411 |
| 1938-39 | 1,111 | 1.32 | 0.05 | 152 | 287 | 13,876 | 269 | 452 |
| 1939-40 | 1,198 | 1.28 | 0.22 | 163 | 267 | 13,040 | 291 | 447 |

Sources of data:

Cols. 1 and 2: California Fruit Growers Exchange. Marketing Research Department. Statistical information on the lemon industry. February, 1942.

Col. 3: United States Bureau of Agricultural Economics. Agricultural prices. Washington, D. C. August 28, 1942. (Mimeo.)

Cols. 4 and 5: Based on expressions (C), see text, equations 1w and 7s and cols. 1, 2, and 3.

Col. 6: Estimated on the basis of equations 1w and 7s and data in cols. 1, 2, and 3.

Cols. 7 and 8: Based on expressions (D), see text, equations 1w and 7s, and cols. 1, 2, 3, and 6.

## Summary

Most of the variation of the average f.o.b. prices of California summer lemons during the twenty-year period 1922 to 1941 can be accounted for by concomitant variation in three factors: namely, (1) total quantity of lemons marketed as fresh fruit in the United States, (2) nonagricultural income payments in the United States, and (3) maximum temperatures prevailing during the summer months. Most of the variation of the average f.o.b. prices of winter lemons can be accounted for by concomitant changes in (1) domestic shipments for fresh consumption of California winter lemons, (2) nonagricultural income payments in the United States, (3) average level of temperatures prevailing in December, January, and February, and (4) trend factors not individually identified but whose aggregate effect is represented by the variable "time." This variable failed to make a significant contribution in the analysis of summer lemons largely because of the presence of a marked trend in the temperature index. Additional evidence, however, makes it probable that during the period the demand for summer lemons relative to annual changes in the purchasing power of consumers and to annual changes in the level of maximum temperatures shifted upward.

In order to obtain a more comprehensive picture of the characteristics of demand for summer and winter lemons, both price and quantity were employed as dependent variables in the regression analysis. In each case the dependent variable (and its logarithm) was expressed as a linear function of the independent variables (and of their logarithms). In addition, equations based on per-capita quantity and per-capita income were fitted. The results secured with these different treatments were found to be in substantial agreement.

On the basis of these analyses several major conclusions appear to be warranted: (1) The demand for summer lemons on an f.o.b. basis was inelastic during the period; the demand for winter lemons on an f.o.b. basis was also inelastic during most of the period. There appears to be little or no difference in the elasticities of demand for summer and winter lemons. (2) Changes in income

have affected the demand for summer and winter lemons. Increases in nonagricultural income payments have been associated with upward shifts of demand for both summer and winter lemons. (3) Changes in weather conditions, more specifically temperature, have affected the demand for both summer and winter lemons. An upward shift of demand for lemons during the summer months is associated with increase in temperatures; an upward shift of demand for lemons during the winter months is associated with decrease in temperatures. (4) During the twenty-year period the demand for both summer and winter lemons, relative to the other independent variables, has shifted upwards. It is likely that factors other than growth of population are responsible for a large part of this upward shift.

The problem of allocation of lemon shipments between the two periods of the marketing year, November to April and May to October, was given brief consideration. Shipments maximizing f.o.b. returns or "value on tree" -- the latter determined under a set of simplifying assumptions -- were found to be, for most of the years of the period, considerably smaller than the actual domestic shipments of winter and summer lemons for fresh consumption. The conclusion that revenue to growers could be increased in the long run if drastic limitation of shipments were instituted is not implied by the foregoing since long-run effects are not treated in the formulations underlying these calculations.

The allocation of a fixed annual volume of shipments to maximize returns to growers was also considered. For the twenty-year period, the allocation of the actual annual shipments so as to maximize returns to growers was shown to result in shipments of winter and summer lemons not greatly different from the actual shipments. However, since 1932-33 there has been apparently a slight but consistent tendency to undership during the months November to April and to overship during the months May to October. This and other evidence suggest that in recent years the shipments of summer lemons were somewhat large relative to the demand conditions prevailing during the year.

were affected and [illegible] for summer and winter [illegible] lemon shipments were [illegible] associated with upward shifts of demand for both summer and winter lemons. (1) Changes in [illegible] have affected [illegible] demand for lemons during the summer months is associated with increases in temperature; an upward shift of demand for lemons during the [illegible] with increases in temperature. (2) During the [illegible] period, the demand for both summer and winter lemons, relative to the other independent variables, has shifted upwards. It is likely that factors other than growth of population are responsible for a large part of this upward shift.

The problem of allocation of lemon shipments between the two types of the [illegible] shipments maximizing f.o.b. returns or "value on tree" -- the latter determined under a set of simplifying assumptions -- [illegible] of the period, considerably smaller than the actual domestic shipments of summer and winter lemons for fresh consumption. The conclusion that [illegible] be increased in the long run if [illegible] allocation of shipments [illegible] is not implied by the foregoing since long-run effects are not treated in determining [illegible] calculations.

The allocation of a fixed annual volume of shipments to maximize returns to [illegible] was also considered. [illegible] actual annual shipments [illegible] shipments of winter and summer lemons [illegible] however, since [illegible] during the months [illegible] may be produced. This and other evidence suggests that in recent years [illegible] of lemon shipments [illegible] during the year.

# APPENDIX A

## Series Used in the Study

The Price Series.-- The price series employed in this paper consist of the average prices, f.o.b. basis, received for lemons marketed by the California Fruit Growers Exchange during the six-month periods November through April and May through October, for each of the twenty years 1921-22 through 1940-41 (see table 13). The average price for each six-month period was obtained by dividing the total amount of money (reduced to an f.o.b. basis) received by the Exchange for lemons shipped during the period, by the number of boxes shipped.

It is impossible to determine directly the degree to which the Exchange prices are representative of prices received for all California lemons since data on sales by other shippers of California lemons are not available to us. Such factors as differentiation of product, variation in time and place of shipments, and variation in composition of shipments would make for differences between prices received by the Exchange and those received by other marketing agencies. However, Exchange prices would exert a predominant influence on the weighted average price for the industry as a whole. For the period under review the California Fruit Growers Exchange has consistently marketed the major proportion of California lemons. For winter lemons, on the average, the Exchange handled about 88 per cent of the total domestic shipments; for summer lemons the Exchange percentage was even higher, approximately 92 per cent. In no year did the Exchange percentage fall below 80 for winter lemons and 86 for summer lemons.[46]

Some notion as to the magnitude of the correlation to be expected between the weighted-average price of lemons marketed by the California Fruit Growers Exchange and the industry weighted-average price may be obtained by the following calculation.

---

[46] These percentages are based on figures given in tables 20 and 21.

# APPENDIX A

[illegible]

The price series.— The yearly price sequence in this paper consists of the [illegible] received for lemons marketed by the California Fruit Growers Exchange [illegible] of money (reduced to an f.o.b. basis) received by the Exchange for lemons shipped during the period, by the number of boxes shipped.

It is impossible to determine directly how closely [illegible] prices are representative of prices received for all California lemons, since data on sales by other shippers of California lemons are not available [illegible]. However, [illegible] would exert a predominant influence on the weighted average price for the industry as a whole. For the period under review the California Fruit Growers Exchange [illegible] For winter lemons, on the average, the Exchange handled about 80 per cent of the [illegible] In no year did the Exchange percentage fall below [illegible] for winter lemons and 26 for summer lemons.[43]

Some notion as to the magnitude of the correlation to be expected between the [illegible] price of lemons received by the California Fruit Growers Exchange and the [illegible] is obtained by the following calculation.

---

[43] These percentages are based on figures given in tables 20 and 21.

## TABLE 13

### Seasonal Average F.O.B. Prices of California Lemons

### 1921-22 to 1940-41

| Year | Period | | Year | Period | |
|---|---|---|---|---|---|
| | November-April | May-October | | November-April | May-October |
| | dollars per box | dollars per box | | dollars per box | dollars per box |
| 1921-22 | 3.48 | 4.48 | 1931-32 | 2.49 | 4.41 |
| 1922-23 | 4.20 | 5.23 | 1932-33 | 3.09 | 3.60 |
| 1923-24 | 2.38 | 2.74 | 1933-34 | 3.20 | 3.85 |
| 1924-25 | 3.87 | 4.93 | 1934-35 | 2.18 | 3.39 |
| 1925-26 | 3.33 | 3.23 | 1935-36 | 3.72 | 4.51 |
| 1926-27 | 2.73 | 4.88 | 1936-37 | 3.79 | 4.86 |
| 1927-28 | 4.81 | 4.86 | 1937-38 | 3.50 | 2.87 |
| 1928-29 | 3.58 | 5.36 | 1938-39 | 2.56 | 3.17 |
| 1929-30 | 4.94 | 5.18 | 1939-40 | 2.99 | 3.04 |
| 1930-31 | 3.09 | 4.50 | 1940-41 | 2.42 | 3.19 |

Source of data:

Based on prices received by the California Fruit Growers Exchange for lemons shipped during these periods. Beginning May, 1926, prices of fruit sold loose are included. Beginning November, 1935, prices of exported lemons are excluded.

On the assumption that the proportion of the total shipments of domestic lemons controlled by the Exchange is constant from year to year and equal to $p_1$, the correlation between the Exchange weighted average price and the industry weighted average price is given by the expression,

$$r_{1t} = \frac{p_1 + k\, p_2\, r_{12}}{\sqrt{p_1^2 + k^2 p_2^2 + 2\, k p_1 p_2\, r_{12}}}$$

where k is the ratio of the standard deviation of the weighted average prices received by shippers outside the Exchange to the standard deviation the Exchange weighted average prices, $r_{12}$ is the correlation between the two sets of weighted average prices, and $p_2 = 1 - p_1$. Considering $r_{1t}$ as a function of $r_{12}$, the minimum value of the former is given for $r_{12} = -\, k\, p_2 p_1^{-1}$, namely,

$$r^o_{1t} = \frac{1}{p_1} \sqrt{p_1^2 - (kp_2)^2}$$

The minimum value of $r_{1t}$ may thus be calculated for various values of $p_1$ and k. The values of $r_{12}$ and $r^o_{1t}$ obtained when to $p_1$ is assigned the value of the ratio of Exchange domestic shipments to industry domestic shipments and to k plausible limits, are given in table 14. Values of $r_{1t}$ obtained when $p_1$ is assigned the lowest observed value during the period under review are also indicated in the table. Under all assumptions, and these by no means favored the appearance of high correlations, the correlation coefficients secured are very high. These results suggest that a satisfactory use in the regression analysis may be made of Exchange prices as approximations to the weighted average industry prices.

Several observations must be made concerning the year-to-year comparability of the series. Beginning with May 1926, prices of lemons sold loose are included in our series. Since prices of packed lemons are available for each of the twenty years under consideration, greater homogeneity might have been achieved by excluding data on loose lemons. However, sales of the latter have increased significantly during the period under review. Rather than to disregard a factor of growing

## TABLE 14

### Estimates of Correlation Between California Fruit Growers Exchange and Industry Weighted Average Prices Under Various Assumptions

| Ratio of C.F.G.E. shipments to industry shipments $p_1$ | $p_2 = 1 - p_1$ | $k = \sigma_2 \sigma_1^{-1}$ | Correlation between C.F.G.E. and outside weighted average prices $r_{12}$ | Correlation between C.F.G.E. and industry weighted average prices $r_{1t}$ | Minimum value of $r_{1t}$ $r^o_{1t}$ |
|---|---|---|---|---|---|
| 0.8752 * | 0.1248 | 1 | -0.1426 | | 0.9898 |
| 0.8752 | 0.1248 | 2 | -0.2852 | | 0.9584 |
| 0.7961 † | 0.2031 | 1 | 0 | 0.9690 | |
| 0.9202 ‡ | 0.0798 | 1 | -0.0867 | | 0.9962 |
| 0.9202 | 0.0798 | 2 | -0.1734 | | 0.9924 |
| 0.8560 § | 0.1440 | 1 | 0 | 0.9862 | |

* Ratio of Exchange domestic shipments of winter lemons 1921-22 through 1940-41 to industry domestic shipments.

† Smallest observed ratio of Exchange domestic shipments of winter lemons to industry domestic shipments for the period 1921-22 through 1940-41.

‡ Ratio of Exchange domestic shipments of summer lemons, 1922 through 1941, to industry domestic shipments.

§ Smallest observed ratio of Exchange domestic shipments of summer lemons to industry domestic shipments for the period 1922 through 1941.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]
for the period [illegible]

importance, it was thought preferable to accept the risk of a slight upward bias in the first four or five observations of the series.

Of possibly greater importance as far as the homogeneity of the price series is concerned is the fact that prior to 1935-36 the series include prices of exported lemons. For the six years for which export data are available, the prices based on domestic shipments differ by as much as 10 cents a box in only one season from prices based on total shipments (see table 15). It is unlikely that differences of this magnitude would be found for the earlier years of the period. Total exports during the last six years were greater relatively than during the previous fourteen years. [47] Furthermore, in the more recent years a somewhat larger proportion of lemons than previously was exported to destinations other than Canada; the f.o.b. prices for the latter country are ordinarily closely in line with prices of like grades and sizes of domestic lemons marketed in continental United States. [48]

Finally, it must be noted that the grade and size composition of shipments varied from year to year (see table 16). The lemons to which the prices refer have not constituted a strictly homogeneous commodity. Had monthly data on grades and sizes been available for the whole of the period, these sources of heterogeneity could have been removed. In the absence of this information we are unable to assess the contribution of these factors to the variance of the f.o.b. prices. [49]

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[47] For the period 1921-22 through 1934-35, exports of domestic winter lemons were 5.8 per cent of total shipments of domestic lemons for fresh consumption; for the period 1935-36 through 1940-41, the percentage of exports was 8.1 per cent. Analogous figures for summer lemons are 4.1 per cent and 7.0 per cent. See data on exports given in tables 17 and 18.

[48] For the period 1925-26 through 1934-35 exports of lemons to Canada comprised approximately 74 per cent of total lemon exports. The corresponding figure for the period 1935-36 through 1939-40 is somewhat less than 60 per cent.

[49] One other possible source of incomparability should be mentioned. In November 1929 the California Fruit Growers Exchange extended its operations to Arizona and from that time on prices of Arizona lemons marketed by the Exchange are included in the price series. The volume of Arizona lemons marketed by the Exchange, however, is negligibly small.

## TABLE 15

### Comparison of F.O.B. Prices of Lemons Excluding and Including Exports, 1935-36 to 1940-41

| Year | November-April | | May-October | |
|---|---|---|---|---|
| | F.o.b. price excluding exports | F.o.b. price including exports | F.o.b. price excluding exports | F.o.b. price including exports |
| | 1 | 2 | 3 | 4 |
| | dollars | dollars | dollars | dollars |
| 1935-36 | 3.72 | 3.75 | 4.51 | 4.49 |
| 1936-37 | 3.79 | 3.81 | 4.86 | 4.87 |
| 1937-38 | 3.50 | 3.49 | 2.87 | 2.82 |
| 1938-39 | 2.56 | 2.51 | 3.17 | 3.07 |
| 1939-40 | 2.99 | 2.99 | 3.04 | 3.04 |
| 1940-41 | 2.42 | 2.42 | 3.19 | 3.19 |

Source of data:

From records of the California Fruit Growers Exchange.

## TABLE 16

Average Sizes of Lemons Shipped by the California Fruit Growers Exchange and Proportion of Shipments Graded Sunkist, 1930-31 to 1940-41

| Year | Average size | | Percentage of shipments graded Sunkist November-October |
|---|---|---|---|
| | November-April | May-October | |
| | 1 | 2 | 3 |
| | Number per box | | Per cent |
| 1930-31 | 334 | 357 | 57.9 |
| 1931-32 | 341 | 363 | 57.3 |
| 1932-33 | 355 | 368 | 58.8 |
| 1933-34 | 363 | 378 | 57.5 |
| 1934-35 | 361 | 355 | 59.8 |
| 1935-36 | 367 | 374 | 55.0 |
| 1936-37 | 379 | 375 | 45.1 |
| 1937-38 | 355 | 359 | 61.3 |
| 1938-39 | 364 | 367 | 54.7 |
| 1939-40 | 363 | 359 | 62.0 |
| 1940-41 | 354 | 349 | 65.3 |

Sources of data:

Cols. 1 and 2: Based on packed lemon shipments of the California Fruit Growers Exchange. Average size for each season was computed by weighting the monthly average sizes by the corresponding monthly shipments.

Col. 3: Based on reports furnished to the California Fruit Growers Exchange by district exchanges. Includes both packed and loose fruit.

The Quantity Series.-- The quantity series employed in the regression analyses are given for winter lemons in table 17 and for summer lemons in table 18. In column 1 of these tables are given estimates of shipments of California and Arizona winter and summer lemons for fresh consumption. Since these are the basic components of the final series, their construction will be described in detail. The sources of the other entries are indicated fully in the notes accompanying the tables.

Estimates of the industry shipments of domestic lemons for fresh consumption were obtained by adjusting the estimates of packed shipments of domestic lemons by the ratio of packed and loose shipments of lemons by the Exchange to their packed domestic shipments. This step in the construction of the series is based on the assumption that the ratio of sales of loose lemons by the industry to total industry sales of lemons is identical with the analogous ratio for the Exchange. The validity of this plausible assumption cannot be directly examined since reliable estimates of sales of loose lemons by shippers outside of the Exchange are not available for any part of the period under review. However, since the Exchange has marketed the major proportion of the California lemon crop in each of the twenty years, the ratio of loose to packed fruit for the industry as a whole could not be very different from the ratio for the Exchange.

In turn, estimates of packed shipments of domestic lemons were obtained by adjusting the Exchange packed shipments by the ratio of industry rail and boat shipments of domestic lemons to the Exchange rail and boat shipments. Industry rail and boat shipments cannot be used directly to represent total industry shipments of lemons, because movement of lemons by truck is not included in these figures, and because of the difficulty of determining the proportion of lemons in mixed citrus car shipments. On the other hand, it is probable that the proportion of lemons in mixed citrus car shipments is not greatly different for shippers outside the Exchange from what it is for the Exchange. This is a plausible assumption and one which affects only a relatively minor subtotal.

*The Domestic Deliveries*.— The domestic series employed in the regression analyses are given for oranges in table 17 and for lemons in table 18. In column 1 of these tables are given estimates of shipments of California and Arizona oranges and lemons for fresh consumption. Since these are the basic components of the fruit series, their construction will be described in detail. The columns of the other series are indicated [illegible] in the notes accompanying the tables.

Estimates of the industry shipments of domestic lemons for fresh consumption were obtained by adjusting the estimates of packed shipments of domestic lemons by the ratio of [illegible] and boat shipments of lemons by the Exchange to their packed domestic shipments. This step in the construction of the series is based on the assumption that the ratio of [illegible] by the industry as well as [illegible] industry sales of lemons is identical with the corresponding ratio for the Exchange. The validity of this plausible assumption [illegible] since the proportion of sales of these lemons to shipments outside of the Exchange are not available for any part of the period under analysis. However, since the Exchange has marketed the major proportion of the California lemon crop in each of the years, the ratio of lemons [illegible] for the industry as a whole would not be very different from the ratio for the Exchange.

In [illegible] estimates of [illegible] shipments of domestic lemons were obtained by adjusting the Exchange packed shipments by the ratio of industry rail and boat shipments of domestic lemons to the Exchange rail and boat shipments. Exchange rail and boat shipments cannot be used directly [illegible] lemons, because movement of lemons by boat is not included in these figures, and because of the difficulty of determining the proportion of lemons in mixed citrus car shipments. On the other hand, it is probable that the proportion of lemons in mixed citrus car shipments is not greatly influenced [illegible] than what it is for the Exchange. This is a plausible assumption and one which affects only a relatively minor subtotal.

## TABLE 17

### Winter Lemons: Domestic Shipments, Per Capita Domestic Shipments, United States Supply, and Per Capita Supply, 1921-22 to 1940-41

| Year November-April | Total shipments | Domestic exports | Domestic shipments | United States population | Per capita domestic shipments | Imports for consumption | United States supply |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | thousand boxes | thousand boxes | thousand boxes | thousand persons | pounds | thousand boxes | thousand boxes |
| 1921-22 | 1,756 | 115 | 1,641 | 109,873 | 1.14 | 384 | 2,025 |
| 1922-23 | 1,388 | 80 | 1,308 | 111,537 | 0.89 | 690 | 1,998 |
| 1923-24 | 2,034 | 123 | 1,911 | 113,202 | 1.28 | 137 | 2,048 |
| 1924-25 | 1,726 | 78 | 1,648 | 114,867 | 1.09 | 384 | 2,032 |
| 1925-26 | 1,860 | 110 | 1,750 | 116,532 | 1.14 | 309 | 2,059 |
| 1926-27 | 2,139 | 185 | 1,954 | 118,197 | 1.26 | 96 | 2,050 |
| 1927-28 | 1,610 | 93 | 1,517 | 119,862 | 0.96 | 505 | 2,022 |
| 1928-29 | 2,291 | 145 | 2,146 | 121,526 | 1.34 | 156 | 2,302 |
| 1929-30 | 1,632 | 74 | 1,558 | 123,077 | 0.96 | 611 | 2,169 |
| 1930-31 | 2,147 | 139 | 2,008 | 124,039 | 1.23 | 69 | 2,077 |
| 1931-32 | 2,122 | 138 | 1,984 | 124,840 | 1.21 | 36 | 2,020 |
| 1932-33 | 1,823 | 62 | 1,761 | 125,578 | 1.07 | 60 | 1,821 |
| 1933-34 | 2,163 | 90 | 2,073 | 126,373 | 1.25 | 8 | 2,081 |
| 1934-35 | 2,779 | 170 | 2,609 | 127,249 | 1.56 | 3 | 2,612 |
| 1935-36 | 2,671 | 332 | 2,339 | 128,052 | 1.39 | 47 | 2,386 |
| 1936-37 | 2,691 | 132 | 2,559 | 128,823 | 1.30 | 8 | 2,567 |
| 1937-38 | 2,433 | 150 | 2,283 | 129,823 | 1.34 | 46 | 2,329 |
| 1938-39 | 2,790 | 299 | 2,491 | 130,878 | 1.45 | -- | 2,491 |
| 1939-40 | 2,964 | 218 | 2,746 | 131,954 | 1.58 | -- | 2,746 |
| 1940-41 | 3,247 | 234 | 3,013 | 133,030 * | 1.72 | -- | 3,013 |

* Estimated.

Sources of data:

Col. 1: Col. 4, table 19.

Col. 2: United States Department of Commerce. Monthly summary of foreign commerce of the United States, monthly issues.

Col. 3: Col. 1 minus col. 2.

Col. 4: United States Department of Commerce Bureau of the Census. Statistical Abstract of the United States, 1941. Population. Estimated as of July 1 for continental United States.

Col. 5: Col. 3 divided by col. 4 and multiplied by 76 for conversion to pounds.

(Continued on next page)

Table 17 continued.

Sources of data:

Col. 6: United States Department of Commerce. Monthly summary of foreign commerce of the United States, monthly issues. 1921-22 through 1932-33: "General imports" minus "exports of foreign lemons." 1933-34 to date: "Imports for consumption." Exports of foreign lemons for November, 1921, through December, 1925, and all import figures converted to boxes on basis of 76 pounds per box.

Col. 7: Col. 3 plus col. 6.

## TABLE 18

Summer Lemons: Domestic Shipments, United States Supply, and Per Capita United States Supply, 1922 to 1941

| Year May-October | Total shipments | Domestic exports | Domestic shipments | Imports for consumption | United States supply | United States population | Per capita United States supply |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | thousand boxes | thousand boxes | thousand boxes | thousand boxes | thousand boxes | thousand persons | pounds |
| 1922 | 2,425 | 78 | 2,347 | 931 | 3,278 | 109,873 | 2.27 |
| 1923 | 2,104 | 85 | 2,019 | 1,096 | 3,115 | 111,537 | 2.13 |
| 1924 | 3,335 | 118 | 3,217 | 468 | 3,685 | 113,202 | 2.48 |
| 1925 | 2,964 | 77 | 2,887 | 1,101 | 3,988 | 114,867 | 2.64 |
| 1926 | 3,442 | 160 | 3,282 | 743 | 4,025 | 116,532 | 2.63 |
| 1927 | 3,043 | 155 | 2,888 | 619 | 3,507 | 118,197 | 2.26 |
| 1928 | 3,162 | 131 | 3,031 | 464 | 3,495 | 119,862 | 2.22 |
| 1929 | 3,377 | 155 | 3,222 | 332 | 3,554 | 121,526 | 2.22 |
| 1930 | 3,437 | 104 | 3,333 | 549 | 3,882 | 123,077 | 2.40 |
| 1931 | 3,941 | 129 | 3,812 | 176 | 3,988 | 124,039 | 2.44 |
| 1932 | 3,167 | 95 | 3,072 | 47 | 3,119 | 124,840 | 1.90 |
| 1933 | 3,567 | 96 | 3,471 | 69 | 3,540 | 125,578 | 2.14 |
| 1934 | 4,180 | 140 | 4,040 | 15 | 4,055 | 126,373 | 2.44 |
| 1935 | 4,535 | 376 | 4,159 | -- | 4,159 | 127,249 | 2.48 |
| 1936 | 4,576 | 302 | 4,274 | 39 | 4,313 | 128,052 | 2.56 |
| 1937 | 3,964 | 124 | 3,840 | 26 | 3,866 | 128,823 | 2.28 |
| 1938 | 4,915 | 570 | 4,345 | -- | 4,345 | 129,823 | 2.55 |
| 1939 | 5,234 | 532 | 4,702 | -- | 4,702 | 130,878 | 2.73 |
| 1940 | 4,857 | 252 | 4,605 | -- | 4,605 | 131,954 | 2.66 |
| 1941 | 5,775 | 276 | 5,499 | -- | 5,499 | 133,030* | 3.14 |

* Estimated.

Sources of data:

Col. 1: Col. 8, table 19.

Col. 2: United States Department of Commerce. Monthly summary of foreign commerce of the United States, monthly issues.

Col. 3: Col. 1 minus col. 2.

Col. 4: United States Department of Commerce. Monthly summary of foreign commerce of the United States, monthly issues. For 1922 through 1933: General imports minus exports of foreign lemons; 1934 to date: Imports for consumption. Exports of foreign lemons for 1922 through 1925 and all import figures converted to boxes on basis of 76 pounds per box.

(continued)

Table 18 continued.

Sources of data:

Col. 5: Col. 3 plus col. 4.
Col. 6: Col. 4 of table 17.
Col. 7: Col. 5 divided by col. 6 and multiplied by 76 for conversion to pounds.

TABLE 19

Industry Shipments of Winter and Summer Lemons for Fresh Consumption, 1921-22 to 1940-41

| Year | November-April | | | | May-October | | | |
|---|---|---|---|---|---|---|---|---|
| | Industry rail and boat shipments | C.F.G.E. rail and boat shipments | C.F.G.E. shipments | Total industry shipments | Industry rail and boat shipments | C.F.G.E. rail and boat shipments | C.F.G.E. shipments | Total industry shipments |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | carlots | carlots | 1,000 boxes | 1,000 boxes | carlots | carlots | 1,000 boxes | 1,000 boxes |
| 1921-22 | 3,881 | 3,368 | 1,523 | 1,756 | 5,751 | 4,922 | 2,076 | 2,425 |
| 1922-23 | 3,439 | 3,224 | 1,301 | 1,388 | 5,215 | 4,972 | 2,006 | 2,104 |
| 1923-24 | 4,987 | 4,579 | 1,867 | 2,034 | 7,954 | 6,819 | 2,859 | 3,335 |
| 1924-25 | 4,285 | 3,879 | 1,562 | 1,726 | 7,306 | 6,750 | 2,738 | 2,964 |
| 1925-26 | 4,623 | 4,287 | 1,725 | 1,860 | 8,771 | 8,007 | 3,143 | 3,442 |
| 1926-27 | 5,573 | 4,479 | 1,719 | 2,139 | 7,641 | 6,860 | 2,732 | 3,043 |
| 1927-28 | 4,067 | 3,735 | 1,479 | 1,610 | 8,224 | 7,617 | 2,928 | 3,162 |
| 1928-29 | 5,894 | 5,169 | 2,009 | 2,291 | 8,460 | 7,675 | 3,064 | 3,377 |
| 1929-30 | 4,018 | 3,636 | 1,477 | 1,632 | 9,010 | 8,319 | 3,174 | 3,437 |
| 1930-31 | 5,493 | 4,685 | 1,831 | 2,147 | 10,072 | 9,195 | 3,598 | 3,941 |
| 1931-32 | 5,402 | 4,397 | 1,727 | 2,122 | 7,910 | 7,291 | 2,919 | 3,167 |
| 1932-33 | 4,593 | 4,060 | 1,610 | 1,823 | 8,943 | 8,004 | 3,193 | 3,567 |
| 1933-34 | 5,143 | 4,513 | 1,898 | 2,163 | 10,515 | 9,586 | 3,810 | 4,180 |
| 1934-35 | 6,649 | 5,294 | 2,213 | 2,779 | 10,877 | 9,928 | 4,140 | 4,535 |
| 1935-36 | 6,128 | 5,242 | 2,285 | 2,671 | 11,003 | 10,123 | 4,209 | 4,576 |
| 1936-37 | 5,347 | 4,803 | 2,417 | 2,691 | 8,526 | 7,994 | 3,717 | 3,964 |
| 1937-38 | 5,169 | 4,534 | 2,133 | 2,433 | 10,753 | 9,793 | 4,476 | 4,915 |
| 1938-39 | 5,908 | 4,784 | 2,260 | 2,790 | 11,173 | 10,107 | 4,734 | 5,234 |
| 1939-40 | 6,271 | 5,000 | 2,363 | 2,964 | 10,215 | 8,907 | 4,235 | 4,857 |
| 1940-41 | 6,885 | 5,260 | 2,481 | 3,247 | 12,554 | 11,067 | 5,091 | 5,775 |
| 1941-42 | 6,369 | 5,544 | 2,621 | 3,011 | 10,546 | 9,494 | 4,376 | 4,861 |

Sources of data:

Cols. 1, 2, 5, and 6: Reported by the railroads to the California Fruit Growers Exchange. Exchange and industry truck shipments are excluded.

Col. 3: From the records of the California Fruit Growers Exchange. Consists of shipments of packed and loose fruit. For 1921-22 through 1925-26 shipments of loose fruit not available, but were estimated to be 2.86 per cent of packed shipments during those years.

(Continued on next page)

Table 19 continued:

Sources of data:

Col. 4: Col. 3 multiplied by col. 1 divided by col. 2.

Col. 7: From the records of the California Fruit Growers Exchange. Consists of shipments of packed and loose fruit. For 1922 through 1925, shipments of loose fruit not available, but were estimated to be 3.02 per cent of packed shipments during those years.

Col. 8: Col. 7 multiplied by col. 5 divided by col. 6.

## TABLE 20

Winter Lemons: California Fruit Growers Exchange Domestic Shipments and Outside Domestic Shipments, 1921-22 to 1940-41

| Year November-April | Domestic shipments | C.F.G.E. shipments | Estimated C.F.G.E. exports | C.F.G.E. domestic shipments | Outside domestic shipments |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| | 1,000 boxes | 1,000 boxes | 1,000 boxes | 1,000 boxes | 1,000 boxes |
| 1921-22 | 1,641 | 1,523 | 100 | 1,423 | 218 |
| 1922-23 | 1,308 | 1,301 | 75 | 1,226 | 82 |
| 1923-24 | 1,911 | 1,867 | 113 | 1,754 | 157 |
| 1924-25 | 1,648 | 1,562 | 71 | 1,491 | 157 |
| 1925-26 | 1,750 | 1,725 | 102 | 1,623 | 127 |
| 1926-27 | 1,954 | 1,719 | 149 | 1,570 | 384 |
| 1927-28 | 1,517 | 1,479 | 86 | 1,393 | 124 |
| 1928-29 | 2,146 | 2,009 | 128 | 1,881 | 265 |
| 1929-30 | 1,558 | 1,477 | 67 | 1,410 | 148 |
| 1930-31 | 2,008 | 1,831 | 118 | 1,713 | 295 |
| 1931-32 | 1,984 | 1,727 | 112 | 1,615 | 369 |
| 1932-33 | 1,761 | 1,610 | 54 | 1,556 | 205 |
| 1933-34 | 2,073 | 1,898 | 78 | 1,820 | 253 |
| 1934-35 | 2,609 | 2,213 | 136 | 2,077 | 532 |
| 1935-36 | 2,339 | | | 2,174 | 165 |
| 1936-37 | 2,559 | | | 2,393 | 166 |
| 1937-38 | 2,283 | | | 2,078 | 205 |
| 1938-39 | 2,491 | | | 2,143 | 348 |
| 1939-40 | 2,746 | | | 2,345 | 401 |
| 1940-41 | 3,013 | | | 2,459 | 554 |

Sources of data:

Col. 1: Col. 3, table 17.

Col. 2: Col. 3, table 19.

Col. 3: Col. 2 of table 17 multiplied by the ratio of California Fruit Growers Exchange rail and boat shipments of lemons to industry rail and boat shipments as reported by the railroads to California Fruit Growers Exchange.

Col. 4: Through 1934-35, col. 2 minus col. 3; beginning 1935-36, reported by the California Fruit Growers Exchange.

Col. 5: Col. 1 minus col. 4.

## TABLE 21

### Summer Lemons: California Fruit Growers Exchange Domestic Shipments and Outside Supply, 1922-1941

| Year May-October | Domestic shipments 1 | C.F.G.E. shipments 2 | Estimated C.F.G.E. exports 3 | C.F.G.E. domestic shipments 4 | Outside domestic shipments 5 | Outside supply 6 |
|---|---|---|---|---|---|---|
| | 1,000 boxes | 1,000 boxes | 1,000 boxes | 1,000 boxes | 1,000 boxes | 1,000 boxes |
| 1922 | 2,347 | 2,076 | 67 | 2,009 | 338 | 1,269 |
| 1923 | 2,019 | 2,006 | 81 | 1,925 | 94 | 1,190 |
| 1924 | 3,217 | 2,859 | 101 | 2,758 | 459 | 927 |
| 1925 | 2,887 | 2,738 | 71 | 2,667 | 220 | 1,321 |
| 1926 | 3,282 | 3,143 | 146 | 2,997 | 285 | 1,028 |
| 1927 | 2,888 | 2,732 | 139 | 2,593 | 295 | 914 |
| 1928 | 3,031 | 2,928 | 121 | 2,807 | 224 | 688 |
| 1929 | 3,222 | 3,064 | 141 | 2,923 | 299 | 631 |
| 1930 | 3,333 | 3,174 | 96 | 3,078 | 255 | 804 |
| 1931 | 3,812 | 3,598 | 117 | 3,481 | 331 | 507 |
| 1932 | 3,072 | 2,919 | 87 | 2,832 | 240 | 287 |
| 1933 | 3,471 | 3,193 | 86 | 3,107 | 364 | 433 |
| 1934 | 4,040 | 3,810 | 128 | 3,682 | 358 | 373 |
| 1935 | 4,159 | 4,140 | 342 | 3,798 | 361 | 361 |
| 1936 | 4,274 | | | 4,078 | 196 | 235 |
| 1937 | 3,840 | | | 3,691 | 149 | 175 |
| 1938 | 4,345 | | | 4,133 | 212 | 212 |
| 1939 | 4,702 | | | 4,453 | 249 | 249 |
| 1940 | 4,605 | | | 4,217 | 388 | 388 |
| 1941 | 5,499 | | | 5,070 | 429 | 429 |

Sources of data:

Col. 1: Col. 3, table 18.

Col. 2: Col. 7, table 19.

Col. 3: Col. 2 of table 18 multiplied by the ratio of California Fruit Growers Exchange rail and boat shipments of lemons to industry rail and boat shipments as reported by the railroads to the California Fruit Growers Exchange.

Col. 4: Through 1935, Col. 2 minus col. 3; beginning 1936, reported by the California Fruit Growers Exchange.

Col. 5: Col. 1 minus col. 4.

Col. 6: Col. 5 plus col. 4 of table 18.

The domestic shipments of winter lemons by the California Fruit Growers Exchange and by all other handlers are given in table 20. Similar data for summer lemons are recorded in table 21. For years prior to 1935-36, shipment figures entered in the permanent records of the Exchange include exports. Exchange exports for the period 1921-22 to 1934-35 were estimated by adjusting industry export figures by the ratio of Exchange rail and boat shipments to industry rail and boat shipments. This adjustment is based on the assumption that the ratio of Exchange exports to Exchange shipments is the same as the ratio of exports by other handlers of California and Arizona lemons to their total shipments.

The Income Series.-- In table 22 are given indexes of nonagricultural income payments based on data published by the United States Department of Agriculture. The entries in this table are simple averages of the monthly indexes for the six-month periods November through April and May through October. 50/ It should, perhaps, be noted here that for the years prior to 1929 the index is based on W. I. King's and the Brookings Institution estimates, 51/ and since 1929 on United States Department of Commerce estimates of income payments.

At least two criticisms may be offered of the use of the index of nonagricultural income payments as a measure of consumer purchasing power. Since lemons are produced by a small proportion of the total number of farmers, total income payments would be a more suitable measure of consumer purchasing power than nonagricultural income payments. However, a still more suitable index would be one based on total income payments from which necessitous expenditures have been

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50/ A description of this index is given in: Bean, L. H., P. H. Bollinger, and O. V. Wells. Nonagricultural income as a measure of domestic demand. 45p. U.S. Agr. Adjust. Admin. June 1937.

51/ The entire series prior to 1929 is published in Leven, Maurice, Harold G. Moulton, and Clark Warburton. America's capacity to consume. p. 152. The Brookings Institution, Washington, D.C., 1934.

[illegible]

[illegible] lemons are recorded in table 21. For years prior to 1933-34, shipment figures [illegible] for the period 1921-22 to 1934-35 were estimated by adjusting industry export figures by the ratio of Exchange rail and boat exports to industry rail and boat shipments. This adjustment is based on the assumption that the ratio of Exchange exports to Exchange shipments is the same as the ratio of exports by other handlers of California and Arizona lemons to their total shipments.

The income series.-- In table 22 are given indexes of nonagricultural income payments based on data published by the United States Department of Agriculture. The entries in this table are simple averages of the monthly indexes for the six-month periods November through April and May through October. [63] It should, perhaps, be noted here that for the years prior to 1929 the index is based on W. I. King's and the Brookings Institution estimates, [64] and since 1929 on United [illegible]

At least two criticisms may be offered of the use of the index of nonagricultural income payments as a measure of consumer purchasing power. Since lemons are [illegible] ments would be a more suitable measure of consumer purchasing power than nonagricultural income payments. However, a still more suitable index would be one [illegible]

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[63] [illegible] Agr. Adjust. Admin. June 1937.

[64] [illegible] Moulton, and Clark Warburton, America's Capacity to Consume, [illegible] The Brookings Institution, Washington, D.C., 1934.

## TABLE 22

### Indexes of Total and Per Capita Nonagricultural Income Payments in the United States, 1921-22 to 1940-41

| Year | Nonagricultural income payments | | Index of nonfarm population 1922 = 100 | Per capita nonagricultural income payments | |
|---|---|---|---|---|---|
| | November-April 1925-29 = 100 | May-October 1935-39 = 100 | | November-April | May-October |
| | 1 | 2 | 3 | 4 | 5 |
| 1921-22 | 71 | 88 | 100 | 71 | 88 |
| 1922-23 | 83 | 100 | 103 | 81 | 97 |
| 1923-24 | 92 | 101 | 105 | 88 | 96 |
| 1924-25 | 93 | 110 | 107 | 87 | 103 |
| 1925-26 | 100 | 113 | 110 | 91 | 103 |
| 1926-27 | 102 | 116 | 112 | 91 | 104 |
| 1927-28 | 102 | 119 | 114 | 89 | 104 |
| 1928-29 | 106 | 123 | 116 | 91 | 106 |
| 1929-30 | 105 | 111 | 118 | 89 | 94 |
| 1930-31 | 91 | 96 | 119 | 76 | 81 |
| 1931-32 | 75 | 74 | 119 | 63 | 62 |
| 1932-33 | 61 | 71 | 120 | 51 | 59 |
| 1933-34 | 69 | 81 | 121 | 57 | 67 |
| 1934-35 | 74 | 87 | 122 | 61 | 71 |
| 1935-36 | 82 | 104 | 123 | 67 | 85 |
| 1936-37 | 93 | 108 | 124 | 75 | 87 |
| 1937-38 | 88 | 99 | 125 | 70 | 79 |
| 1938-39 | 90 | 107 | 126 | 71 | 85 |
| 1939-40 | 97 | 114 | 127* | 76 | 90 |
| 1940-41 | 109 | 135 | 128* | 85 | 105 |

*Estimated.

Sources of data:

Col. 1: 1921 to May, 1941: United States Bureau of Agricultural Economics. Nonagricultural income payments, United States, 1919 to date. 2p. Washington, D. C., July 21, 1941. (Mimeo.) June, 1941 on: United States Department of Commerce. Survey of Current Business, monthly issues, adjusted by 88.105 per cent. Figures are simple averages of seasonally corrected monthly indexes. Loans and payments to World War veterans on their adjusted service certificates in 1931 and 1936 are excluded. In the other years veteran bonus payments were of little significance.

Col. 2: United States Bureau of Agricultural Economics. Nonagricultural income payments, United States, 1909-41. 2p. Washington, D. C. February 2, 1942. Figures are simple averages of seasonally corrected monthly indexes. Loans and payments to World War veterans on their adjusted service certificates in 1931 and 1936 are excluded.

Col. 3: Col. 4 of table 17 minus estimates of farm population given in: United States Bureau of Agricultural Economics. Farm population estimates. Released July, 1940. (Mimeo.) Adjusted as of July 1 of each year.

Col. 4: Col. 1 divided by col. 3.

Col. 5: Col. 2 divided by col. 3.

subtracted. The demand for most consumer goods, one would suppose, is affected not so much by total income payments as by the amount of freely disposable income available to the consumers.

At the time the calculations reported in this paper were made, estimates of total income payments on other than calendar year basis were not available for years prior to 1929. Later, total income payments for November-April and May-October of each year were estimated by the senior author for use in another demand study. Estimates of disposable income were also prepared by subtracting, from total income payments to individuals, necessitous living expenditures, medical expenditures, and selected federal taxes. While the three indexes -- namely, nonagricultural income payments, total income payments to individuals, and disposable income -- exhibited some differences, their year-to-year fluctuations were strikingly similar. The correlations between the three November-April indexes for the period 1922-23 through 1939-40 were $r_{ab} = .992$, $r_{ac} = .984$, and $r_{bc} = .996$; the correlations for May-October were $r_{ab} = .991$, $r_{ac} = .984$, and $r_{bc} = .998$ (a = nonagricultural income payments, b = total income payments, c = residual income). In view of the magnitude of these correlations it is doubtful that extensive recalculations were warranted.

Indexes of Summer and Winter Temperatures.-- The construction of a temperature index raises a number of troublesome questions. What should be the basic unit of time in which temperatures are to be collected? Should mean, maximum or minimum temperatures be used? For what localities should temperatures be recorded? Should actual temperatures, departures from normal in a given area, or departures from some arbitrary level constant for all localities be calculated? How should temperatures be combined? Extensive trial may supply appropriate answers to all of these questions, but extensive trial is time-consuming. Practical considerations make it impossible to avoid arbitrariness in the construction of the index.

The index of summer temperatures constructed for this study consists, for each of the twenty six-month periods, of the sum of weighted daily positive departures of maximum temperatures from 80° Fahrenheit in 39 metropolitan areas (see

table 23). Population weights were used in calculating the daily weighted means.

In order to insure a satisfactory degree of sensitiveness to the index, it appeared advisable to employ as its basic component daily maximum temperatures. Considering the intended use of this variable, it is clear that a geographically representative measure of temperature would not be particularly suitable. Rather an index which summarized temperature conditions in the densely populated areas of this country was required. This led to a consideration of metropolitan districts as areas for which temperature data should be secured. The 39 metropolitan districts selected were the urban centers largest in population. The exclusion of predominantly rural areas is open to criticism, since the available evidence suggests that the per-capita consumption of lemons in rural areas is nearly on par with the per-capita consumption in urban districts.[52] The geographical extensiveness of rural regions, however, has precluded their inclusion in the index.

It is likely that the relation between temperature and consumption of cold drinks has a lower bound within the range of observed temperatures; below a certain point changes in temperature fail to have a measurable effect on the consumption of cold drinks. This consideration suggests the use of positive departures of maximum temperatures from some level. For this purpose a constant reference point, namely 80° Fahrenheit, was employed for all districts and for all days. The use of a changing reference level, such as the "normal" maximum temperature in a certain district for a given day, would have partialled out the effect of differences between the general levels of temperature in the various metropolitan areas. It appeared desirable, however, that the index in part reflect such differences. The selection of 80° Fahrenheit as the reference level is, of course, arbitrary, but the use of any other reference point, provided that it was not extreme, would have, in all likelihood, given approximately the same results.

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[52] Annual report of the general manager of the California Fruit Growers Exchange for 1937. 36p.

table 15). Population weights were used in calculating the daily weighted means.

In order to insure a satisfactory degree of sensitiveness to the index, it appeared advisable to employ as its basic component daily maximum temperatures. Considering the intended use of this variable, it is clear that a geographically representative measure of temperature would not be particularly suitable. Rather an index which summarized temperature conditions in the densely populated areas of this country was required. This led to a consideration of metropolitan districts as areas for which temperature data [illegible] be computed. The metropolitan districts [illegible] in open [illegible] [illegible] per-capita consumption of lemons in rural [illegible] that the per-capita consumption of lemons in rural areas is nearly on par with the per-capita consumption in urban districts. The geographical extensiveness of [illegible]

It is [illegible] [illegible] for all districts and for all days [illegible] was employed for all districts' maximum temperatures. The use of a [illegible] district for a given day would have [illegible] the effect of differences between the general levels of temperature in the [illegible] metropolitan areas. It [illegible] selection of 80° Fahrenheit as the reference level is, of course, arbitrary, but the use of any other reference point, provided that it was not extreme, would have [illegible]

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[illegible]

## TABLE 23

### Indexes of Winter and Summer Temperatures

### 1921-22 to 1940-41

| Year | Index of temperatures December-February * | Index of temperatures May-October † | Year | Index of temperatures December-February * | Index of temperatures May-October † |
|---|---|---|---|---|---|
| | 1 | 2 | | 3 | 4 |
| | per cent | per cent | | per cent | per cent |
| 1921-22 | 81 | 100 | 1931-32 | 100 | 110 |
| 1922-23 | 78 | 92 | 1932-33 | 91 | 136 |
| 1923-24 | 85 | 80 | 1933-34 | 76 | 142 |
| 1924-25 | 82 | 120 | 1934-35 | 79 | 106 |
| 1925-26 | 80 | 88 | 1935-36 | 67 | 151 |
| 1926-27 | 82 | 75 | 1936-37 | 90 | 127 |
| 1927-28 | 84 | 89 | 1937-38 | 84 | 115 |
| 1928-29 | 81 | 105 | 1938-39 | 87 | 140 |
| 1929-30 | 86 | 138 | 1939-40 | 77 | 106 |
| 1930-31 | 87 | 150 | 1940-41 | 83 | 145 |

* 1931-32 =100.

† 1922 = 100.

Sources of data:

Cols. 1 and 3: United States Weather Bureau, Climatic Summary of the United States, United States Meteorological Yearbook and Climatological Data for the United States by sections. Monthly mean temperatures December through February in 32 cities weighted by the population in the corresponding metropolitan districts. The weights employed are given in table 24.

Cols. 2 and 4: United States Weather Bureau, Climatological Data for the United States by sections. Positive departures of daily maximum temperatures in 39 cities from 80°, May through October, weighted by the population in the corresponding metropolitan districts. The weights employed are given in table 24.

One other item requires mention in connection with the construction of the index, namely the weights employed in the calculation of the daily means. As was indicated previously, the positive departures of maximum temperatures from 80° Fahrenheit in each of the 39 metropolitan districts were weighted by the population in the district. For this purpose the population figures from the censuses of 1920, 1930, and 1940 were employed as weights for periods 1922 through 1925, 1926 through 1934, and 1935 through 1941 respectively (see table 24). The use of the three sets of weights was deemed sufficient to account for the relative shifts of populations in these areas.

Other weights, such as average unloads of lemons in each of the metropolitan districts [53] or even income figures for each area, might have been employed in place of the weights we have used, or in conjunction with them. The weighting employed is based on the simple hypothesis that, at each level of temperature, consumption of cold drinks is a single-valued monotonically increasing function of the number of persons exposed to the temperature. The weighting disregards possible regional differences in lemon consumption, but it is doubtful that there is marked regional variation in the use of lemons in cold drinks. [54] If simple rather than composite weighting is to be employed, weights based on population appeared to be superior to other feasible types of weights.

The index of temperatures employed in the analysis of demand for winter lemons is based on mean temperatures during December, January, and February in 32 metropolitan districts. The weighted mean temperature for each of the three months

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[53] See appendix E for the use of average unloads as weights.

[54] The data in table 1 suggest the existence of at least one regional difference in consumption of lemons, namely that between the southeastern region of the United States and other regions considered in the Study of Consumer Purchases. The data reported in table 1 were secured during the months May through August of 1936. Analogous data secured during the months September through November, certainly a cooler period, reveal about the same difference between lemon consumption in the southeast and in the other regions. Thus it is not clear that this regional differential is related to the use of lemons in thirst-quenching beverages.

One other item requires mention in connection with the construction of the index, namely the weights employed in the calculation of the daily means. As was indicated previously, the positive departures of maximum temperatures from 80° Fahrenheit in each of the 35 metropolitan districts were weighted by the population in the districts. For this purpose the population figures from the censuses of 1920, 1930, and 1940 were employed as weights for periods 1922 through 1925, 1926 through 1935, and 1936 through 1941 respectively (see table 44). The use of the three sets of weights was deemed sufficient to account for the relative shifts of populations in these areas.

Other weights, such as carloads of lemons in each of the metropolitan districts or even income figures for each area, might have been employed in place of the weights we have used, or in conjunction with them. The weighting employed is based on the simple hypothesis that, at each level of temperature, consumption of cold drinks is a single-valued monotonically increasing function of the number of persons exposed to the temperature. The weighting disregards possible regional differences in lemon consumption, but it is doubtful that there is marked regional variation in the use of lemons in cold drinks. If simple rather than complex weighting is to be employed, weights based on population appeared to be superior to other feasible types of weights.

The index of the temperature employed in the analysis of demand for winter lemons is based on mean temperatures during December, January, and February in 32

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[illegible]

[illegible] in thirst-quenching beverages.

## TABLE 24

### Population Weights Employed in the Construction of Indexes of Summer and Winter Temperatures

| Metropolitan districts | May-October index | | | December-February index | | |
|---|---|---|---|---|---|---|
| | 1922 through 1925 | 1926 through 1934 | 1935 through 1941 | 1921-22 through 1924-25 | 1925-26 through 1933-34 | 1935-36 through 1940-41 |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Albany - Schenectady - Troy, N. Y. | .011 | .010 | .009 | .012 | .011 | .011 |
| Atlanta, Georgia | .008 | .008 | .009 | | | |
| Baltimore, Maryland | .024 | .021 | .022 | .026 | .024 | .025 |
| Birmingham, Alabama | .008 | .009 | .009 | | | |
| Boston, Massachusetts | .058 | .052 | .049 | .064 | .059 | .057 |
| Buffalo, New York | .019 | .018 | .018 | .022 | .021 | .021 |
| Chicago, Illinois | .095 | .098 | .094 | .105 | .112 | .109 |
| Cincinnati, Ohio | .018 | .017 | .016 | .020 | .019 | .019 |
| Cleveland, Ohio | .027 | .027 | .025 | .030 | .031 | .029 |
| Columbus, Ohio | .008 | .008 | .008 | .009 | .009 | .009 |
| Dallas, Texas | .006 | .007 | .008 | | | |
| Denver, Colorado | .008 | .007 | .008 | .009 | .008 | .009 |
| Detroit, Michigan | .036 | .047 | .048 | .040 | .054 | .056 |
| Hartford, Connecticut | .011 | .011 | .010 | .012 | .012 | .012 |
| Houston, Texas | .005 | .008 | .011 | | | |
| Indianapolis, Indiana | .010 | .009 | .009 | .011 | .011 | .011 |
| Kansas City (Kansas, Missouri) | .014 | .014 | .013 | .015 | .016 | .015 |
| Los Angeles, California | .031 | .052 | .061 | | | |
| Louisville, Kentucky | .010 | .009 | .009 | .011 | .010 | .011 |
| Memphis, Tennessee | .005 | .006 | .007 | .006 | .007 | .008 |
| Milwaukee, Wisconsin | .016 | .017 | .016 | .018 | .019 | .019 |
| Minneapolis - St. Paul, Minnesota | .020 | .019 | .019 | .022 | .021 | .022 |
| New Orleans, Louisiana | .012 | .011 | .011 | | | |
| New York - Northeastern New Jersey | .247 | .245 | .244 | .273 | .279 | .283 |
| Oklahoma City, Oklahoma | .003 | .005 | .005 | .003 | .005 | .005 |
| Omaha, Neb. - Council Bluffs, Iowa | .007 | .006 | .006 | .008 | .007 | .007 |
| Philadelphia, Pennsylvania | .071 | .064 | .060 | .079 | .073 | .070 |
| Pittsburgh, Pennsylvania | .049 | .044 | .042 | .055 | .050 | .048 |
| Portland, Oregon | .009 | .009 | .008 | .010 | .010 | .010 |
| Providence, Rhode Island | .025 | .022 | .021 | .028 | .025 | .024 |

(Continued on next page)

Table 24 continued.

| Metropolitan districts | May-October index | | | December-February index | | |
|---|---|---|---|---|---|---|
| | 1922 through 1925 | 1926 through 1934 | 1935 through 1941 | 1921-22 through 1924-25 | 1925-26 through 1933-34 | 1935-36 through 1940-41 |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Richmond, Virginia | .006 | .005 | .005 | .006 | .006 | .006 |
| Rochester, New York | .010 | .009 | .009 | .011 | .010 | .010 |
| St. Louis, Missouri | .031 | .029 | .029 | .034 | .033 | .033 |
| Salt Lake City, Utah | .004 | .004 | .004 | .005 | .005 | .005 |
| San Francisco - Oakland, California | .028 | .029 | .030 | | | |
| Scranton - Wilkes Barre, Pa. | .017 | .015 | .013 | .019 | .017 | .015 |
| Seattle, Washington | .010 | .009 | .009 | .011 | .011 | .011 |
| Toledo, Ohio | .008 | .008 | .007 | .009 | .009 | .008 |
| Washington, D.C. | .015 | .014 | .019 | .017 | .016 | .022 |
| Total population | 34,489,191 | 44,519,745 | 47,950,608 | 31,144,016 | 39,009,662 | 41,340,367 |

Sources of data:

Cols. 1 and 4: Population figures for 1920 from United States Bureau of the Census, Fifteenth Census of the United States, 1930. Metropolitan Districts, Population and Area. Govt. Print. Off., Washington, 1932, expressed as ratios of the total population in the cited metropolitan districts.

Cols. 2, 3, 5, and 6: Population figures for 1930 and 1940 from United States Bureau of the Census, Sixteenth Census of the United States, 1940, Population, first series, Number of Inhabitants, United States Summary. Govt. Print. Off., Washington, 1941, expressed as ratios of the total population in the cited metropolitan districts.

was obtained by weighting the mean monthly temperatures in the 32 districts by the population in each district. As before, three different sets of population figures were employed, based on the 1920, 1930, and 1940 population counts and applied respectively to the periods 1921-22 through 1924-25, 1925-26 through 1933-34, and 1934-35 through 1940-41 (see table 24). The final figure for each year is the sum of the weighted mean temperatures in December, January, and February adjusted for the difference in the number of days in these months.

Index of Influenza.-- The index of influenza given in table 25 is based on the incidence of influenza statistics reported by the various state health boards to the United States Public Health Service. Considerable caution must be exercised in the use of this index. Incidence of influenza figures are far from complete for even the most recent years. Not all of the states have or are reporting nonfatal cases of influenza and, for states which do report, varous degrees of underreporting are to be expected.

The index was constructed by calculating the link relatives of the incidences for states reporting influenza in two successive years. The number of states on which the relatives are based varied, of course, from year to year. An alternative procedure would have been to base the index on a constant sample of states, that is, on states that have reported for each year of the period under review. It is felt that the first procedure yields a more reliable index since it utilizes a larger number of reports. However, an index based on data secured from states which have reported influenza cases throughout the period showed excellent agreement with the index reported in table 25. The major difference between the two indexes was the greater magnitude for epidemic years of the values of the index based on a constant number of states.

was obtained by weighting the mean temperatures in the 22 districts by the population in each district. Specifically, three different sets of population figures were employed, based on the 1920, 1930, and 1940 population counts and applied [illegible] 1924-25 through 1940-44 (see Table [illegible]). The final figure for each year is the sum of the weighted mean temperatures in December, January, and February adjusted for the difference in the number of days in these months.

Index of influenza.—The index of influenza given in Table 26 is based on the incidence of the weekly statistics reported by the various state health bureaus to the United States Public Health Service. Considerable caution must be exercised in the use of this index. Statistics of influenza figures are far from complete for even the most recent years. Not all of the states have or are reporting the [illegible] of influenza and [illegible] are to be expected.

The index was computed by [illegible] the link relatives of the instances for states reporting influenza in two successive years. The number of states on which the relatives are based ranged, of course, from year to year. An alternative procedure would have been to compute the index on a constant sample of states, that is, on states that have reported for each year of the period under review. It is felt that the first procedure yields a more reliable index since it utilizes a larger number of reports. [illegible] which have reported influenza throughout the period showed excellent agreement with the index reported in Table 26. The major difference between the two indexes was the greater amplitude for epidemic years of the values of the index based on a constant number of states.

## TABLE 25

### Index of the Incidence of Influenza, 1921-22 to 1940-41

| Year, November-April | Index of incidence of influenza | Year, November-April | Index of incidence of influenza |
|---|---|---|---|
| | per cent | | per cent |
| 1921-22 | 64 | 1931-32 | 21 |
| 1922-23 | 100 | 1932-33 | 90 |
| 1923-24 | 13 | 1933-34 | 13 |
| 1924-25 | 44 | 1934-35 | 28 |
| 1925-26 | 64 | 1935-36 | 38 |
| 1926-27 | 21 | 1936-37 | 63 |
| 1927-28 | 24 | 1937-38 | 15 |
| 1928-29 | 176 | 1938-39 | 33 |
| 1929-30 | 12 | 1939-40 | 44 |
| 1930-31 | 26 | 1940-41 | 152 |

Source of data:

United States Public Health Service. Public Health Reports. The figures are link relatives reduced to 1922-23 base.

# APPENDIX B

## Price and Quantity Residuals and Tests of Randomness

## TABLE 26

### Summer Lemons: Price and Quantity Residuals

| Year May-October | Equation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1s | 2s | 3s | 4s | 5s | 6s | 7s | 8s | 9s | 10s |
| | dollars | 10,000 boxes | dollars | pounds | logs | logs | dollars | 10,000 boxes | dollars | 10,000 boxes |
| 1922 | 0.12 | 3 | 0.23 | 0.04 | 0.005 | -0.002 | 0.03 | 4 | 0.06 | 4 |
| 1923 | 0.24 | 3 | 0.18 | 0.00 | -0.004 | -0.012 | 0.15 | 4 | 0.20 | 4 |
| 1924 | -0.79 | -28 | -0.65 | -0.12 | -0.099 | -0.034 | -0.78 | -27 | -0.81 | -28 |
| 1925 | 0.48 | 18 | 0.64 | 0.15 | 0.059 | 0.022 | 0.32 | 20 | 0.40 | 20 |
| 1926 | -0.37 | -11 | -0.22 | -0.01 | -0.021 | -0.002 | -0.44 | -10 | -0.40 | -10 |
| 1927 | 0.45 | 17 | 0.37 | 0.07 | 0.061 | 0.022 | 0.49 | 17 | 0.46 | 17 |
| 1928 | -0.12 | -10 | -0.18 | -0.07 | -0.001 | -0.007 | -0.05 | -11 | -0.08 | -11 |
| 1929 | -0.14 | -15 | -0.23 | -0.10 | -0.012 | -0.015 | -0.05 | -16 | -0.10 | -16 |
| 1930 | -0.04 | -10 | -0.04 | -0.03 | -0.007 | -0.012 | -0.08 | -9 | -0.07 | -9 |
| 1931 | -0.17 | -12 | -0.09 | -0.04 | -0.016 | -0.012 | -0.17 | -11 | -0.18 | -11 |
| 1932 | 0.07 | 0 | 0.00 | -0.03 | -0.001 | -0.005 | 0.15 | -1 | 0.12 | -2 |
| 1933 | -0.48 | -21 | -0.46 | -0.12 | -0.040 | -0.017 | -0.47 | -21 | -0.48 | -21 |
| 1934 | 0.22 | 12 | 0.27 | 0.07 | 0.034 | 0.017 | 0.22 | 12 | 0.21 | 12 |
| 1935 | 0.71 | 39 | 0.71 | 0.21 | 0.085 | 0.046 | 0.74 | 39 | 0.73 | 39 |
| 1936 | 0.11 | 3 | 0.11 | 0.01 | 0.016 | 0.004 | 0.13 | 2 | 0.13 | 2 |
| 1937 | 0.06 | -2 | -0.03 | -0.04 | 0.011 | -0.001 | 0.15 | -3 | 0.12 | -4 |
| 1938 | -0.21 | -1 | -0.25 | -0.02 | -0.034 | -0.004 | -0.17 | -1 | -0.17 | -2 |
| 1939 | -0.25 | -5 | -0.31 | -0.04 | -0.036 | -0.001 | -0.25 | -5 | -0.24 | -5 |
| 1940 | 0.08 | 13 | -0.06 | 0.03 | 0.010 | 0.015 | 0.13 | 12 | 0.10 | 12 |
| 1941 | 0.02 | 10 | -0.06 | 0.04 | -0.012 | 0.004 | 0.01 | 10 | 0.00 | 10 |

Source of data: Derived from equations 1s through 10s of tables 3 and 6 applied to data given in table 2.

## TABLE 27

### Summer Lemons: Tests of Randomness of Residuals

| Equation | Lagged correlation coefficient | Wallis and Moore test | |
|---|---|---|---|
| | | $x_p^2$ | $P(x_p^2)$ |
| | 1 | 2 | 3 |
| 1s | -0.3563 | 0.816 | 0.70 |
| 2s | -0.0706 | 3.149 | 0.26 |
| 3s | -0.2349 | 0.298 | 0.88 |
| 4s | 0.3848 | 1.502 | 0.53 |
| 5s | -0.1399 | 0.416 | 0.84 |
| 6s | 0.1304 | 2.395 | 0.36 |
| 7s | -0.2982 | 0.816 | 0.70 |
| 8s | -0.0802 | 3.149 | 0.26 |
| 9s | -0.3280 | 0.816 | 0.70 |
| 10s | -0.0785 | 3.149 | 0.26 |

Sources of data:

Col. 1: Correlations of residuals lagged one year, based on data given in table 26. The 1 per cent significance point for N = 20 at the negative tail is -0.524. (Anderson, R. L. Distribution of the serial correlation coefficient. Annals of Mathematical Statistics 13:1-13, 1942.)

Cols. 2 and 3: Based on data given in table 26 and calculated by combining all phases of more than two years. A given entry in col. 3 gives the probability that a $x_p^2$ of the magnitude of the corresponding entry in col. 2 or larger would be obtained in a random time series. For details of the test, see Wallis, W. A. and G. H. Moore. A significance test for time series and other ordered observations. National Bureau of Economic Research Tech. Paper 1. September, 1941.

# TABLE 28

## Winter Lemons: Price and Quantity Residuals

| Year November-April | Equation | | | | | |
|---|---|---|---|---|---|---|
| | 1w | 2w | 3w | 4w | 5w | 6w |
| | dollars | 1,000 boxes | dollars | pounds | logs | logs |
| 1921-22 | 0.59 | 219 | 0.61 | 0.14 | 0.070 | 0.045 |
| 1922-23 | -0.15 | -86 | -0.27 | -0.08 | -0.067 | -0.050 |
| 1923-24 | -0.30 | -24 | -0.28 | -0.01 | -0.047 | -0.006 |
| 1924-25 | 0.17 | 48 | 0.15 | 0.02 | 0.029 | 0.014 |
| 1925-26 | -0.47 | -142 | -0.46 | -0.09 | -0.038 | -0.018 |
| 1926-27 | -0.58 | -148 | -0.52 | -0.08 | -0.056 | -0.020 |
| 1927-28 | 0.26 | 11 | 0.26 | 0.01 | 0.017 | -0.009 |
| 1928-29 | 0.40 | 151 | 0.45 | 0.10 | 0.086 | 0.053 |
| 1929-30 | 0.28 | 1 | 0.30 | 0.00 | 0.023 | -0.009 |
| 1930-31 | -0.10 | -26 | -0.08 | -0.01 | 0.013 | 0.009 |
| 1931-32 | 0.10 | 48 | 0.07 | 0.02 | 0.003 | 0.006 |
| 1932-33 | -0.16 | -89 | -0.18 | -0.06 | -0.005 | -0.012 |
| 1933-34 | -0.23 | -91 | -0.22 | -0.05 | -0.008 | -0.008 |
| 1934-35 | 0.13 | 105 | 0.09 | 0.06 | -0.025 | 0.003 |
| 1935-36 | 0.04 | -10 | 0.06 | 0.00 | 0.014 | 0.003 |
| 1936-37 | | | | | | |
| 1937-38 | 0.10 | -3 | 0.16 | 0.01 | 0.040 | 0.014 |
| 1938-39 | -0.29 | -89 | -0.27 | -0.05 | -0.036 | -0.019 |
| 1939-40 | 0.07 | 33 | 0.05 | 0.02 | 0.008 | 0.006 |
| 1940-41 | 0.13 | 90 | 0.07 | 0.04 | -0.022 | -0.003 |

Source of data:

Derived from equations 1w through 6w of table 8 applied to data given in table 7.

## TABLE 29

### Winter Lemons: Tests of Randomness of Residuals

| Equation | Lagged correlation coefficient | Wallis and Moore test | |
|---|---|---|---|
| | | $x_P^2$ | $P(x_P^2)$ |
| | 1 | 2 | 3 |
| 1w | 0.0583 | 3.399 | 0.23 |
| 2w | -0.0888 | 6.862 | 0.05 |
| 3w | 0.0668 | 3.399 | 0.23 |
| 4w | -0.1399 | 1.468 | 0.53 |
| 5w | -0.0471 | 5.668 | 0.09 |
| 6w | -0.1040 | 4.399 | 0.15 |

Sources of data:

Col. 1: Correlations of residuals lagged one year, based on data given in table 28. The 1 per cent significance point for N = 15 at the negative tail is -0.597. (Anderson, R. L. Distribution of the serial correlation coefficient. Annals of Mathematical Statistics 13:1-13, 1942.)

Cols. 2 and 3: Based on data given in table 28 for 1921-22 through 1935-36 and calculated by combining all phases of more than two years. A given entry in col. 3 gives the probability that a $x_P^2$ of the magnitude of the corresponding entry in col. 2 or larger would be obtained in a random time series. For details of the test, see Wallis, W. A. and G. H. Moore. A significance test for time series and other ordered observations. National Bureau of Economic Research Tech. Paper 1. September, 1941.

# APPENDIX C

## Net Regression Charts

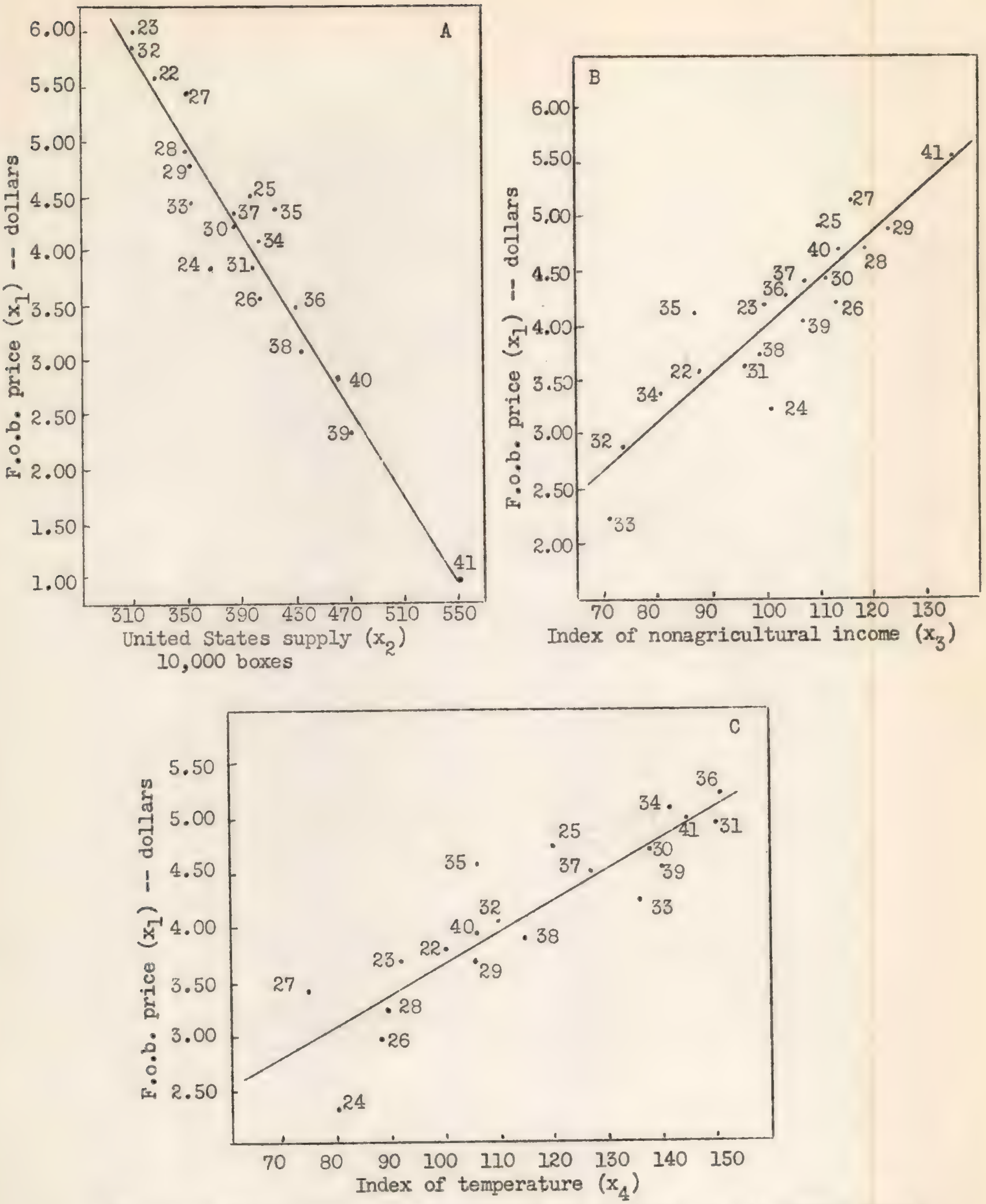


Fig. 3.-- Summer lemons: Net regressions of price on (A) United States supply ($x'_{12} = 12.1856 - 0.0205\ x_2$), (B) index of nonagricultural income payments ($x'_{13} = -0.4630 + 0.0445\ x_3$), and (C) index of temperature ($x'_{14} = 0.8536 + 0.0282\ x_4$), 1922-1941. Arithmetic form.

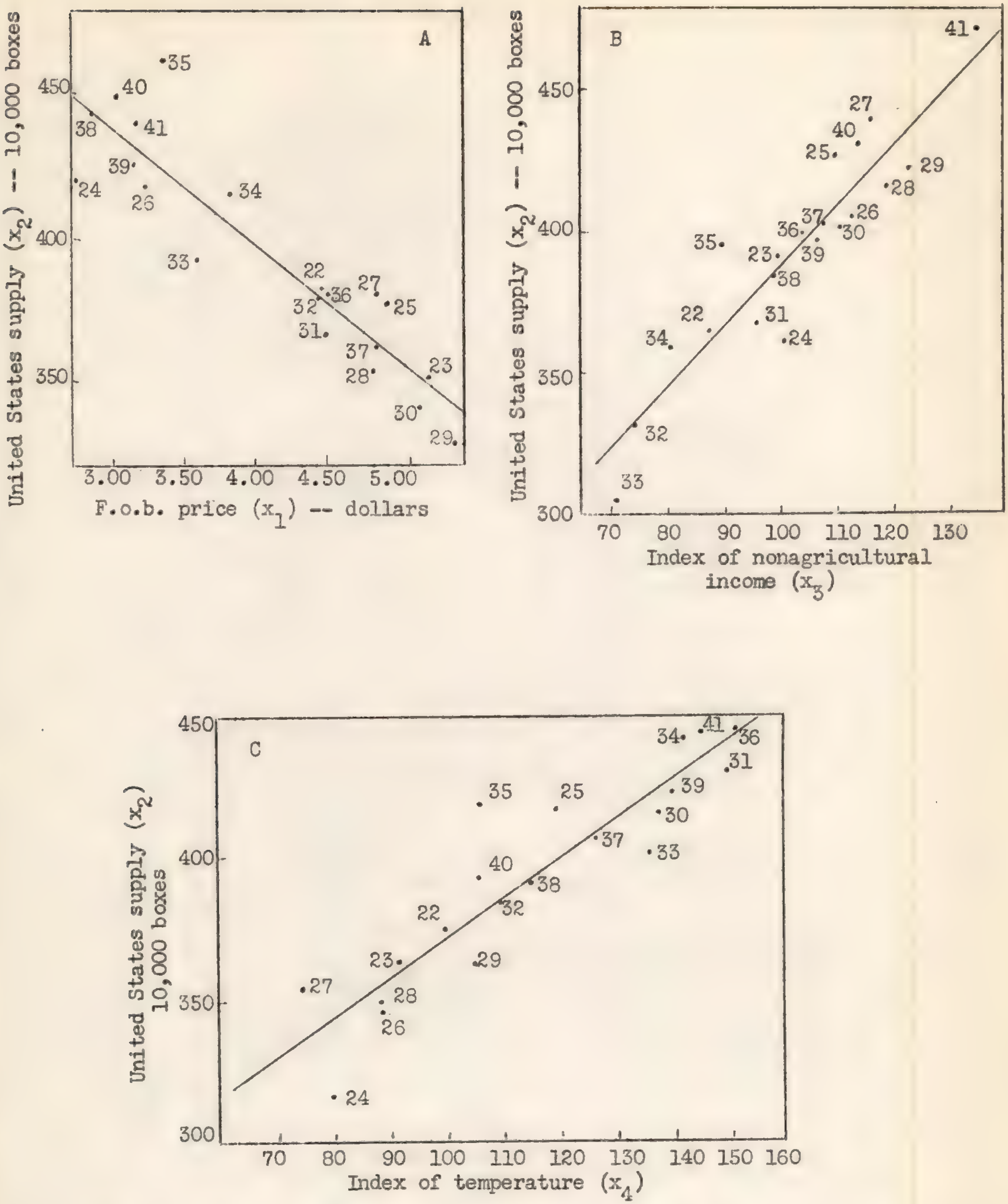


Fig. 4.-- Summer lemons: Net regressions of United States supply on (A) price ($x'_{21} = 563.4914 - 41.2473\ x_1$), (B) index of nonagricultural income payments ($x'_{23} = 175.3618 + 2.1239\ x_3$), and (C) index of temperature ($x'_{24} = 234.3614 + 1.3774\ x_4$), 1922-1941. Arithmetic form.

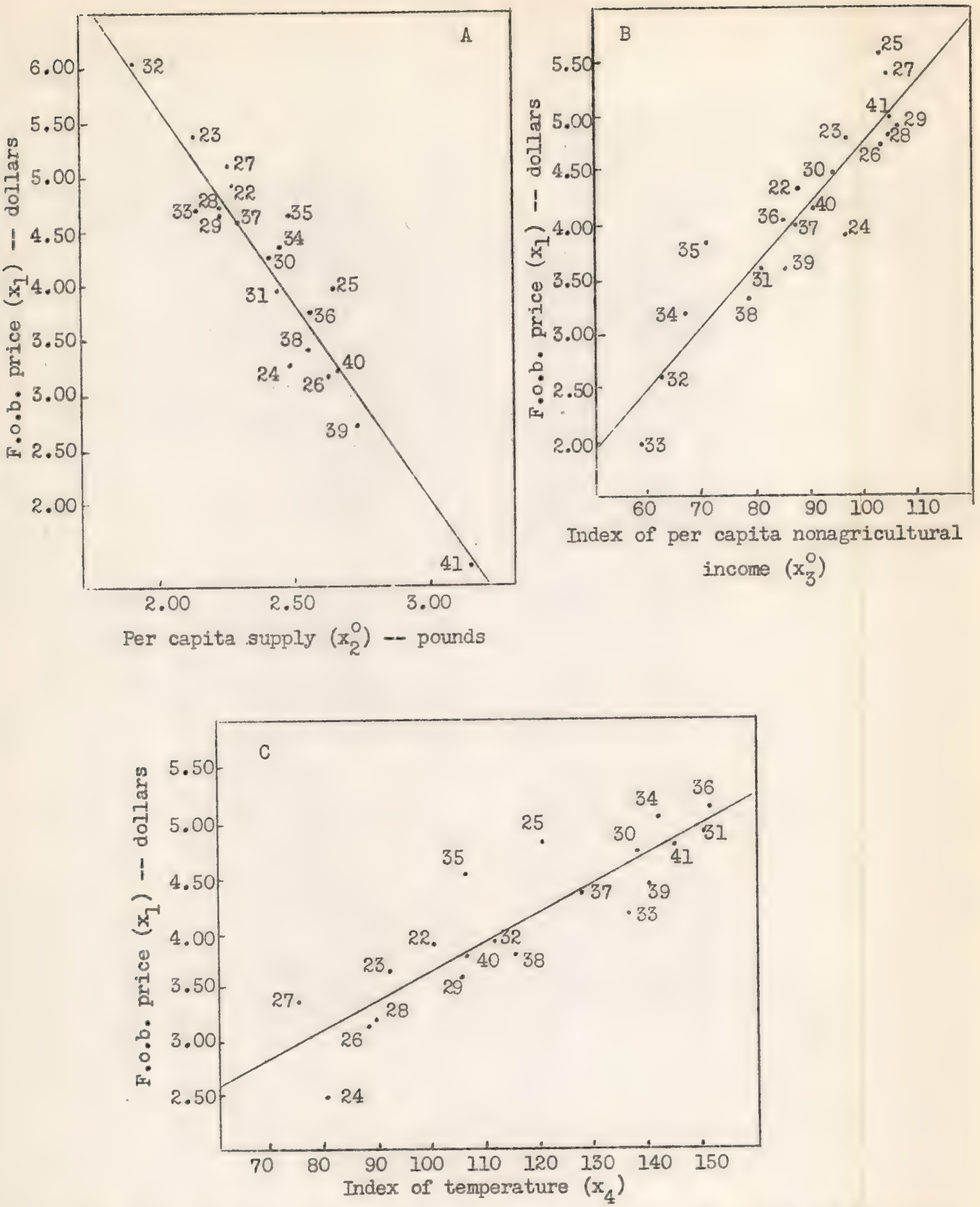
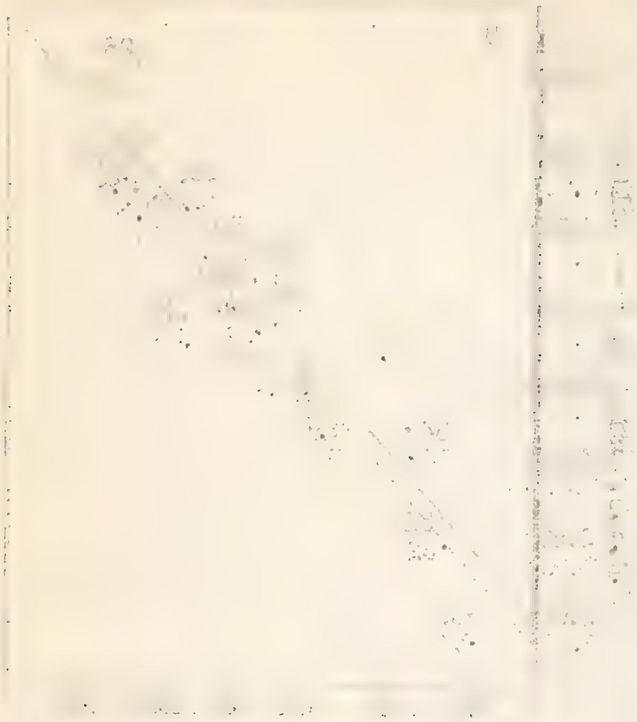
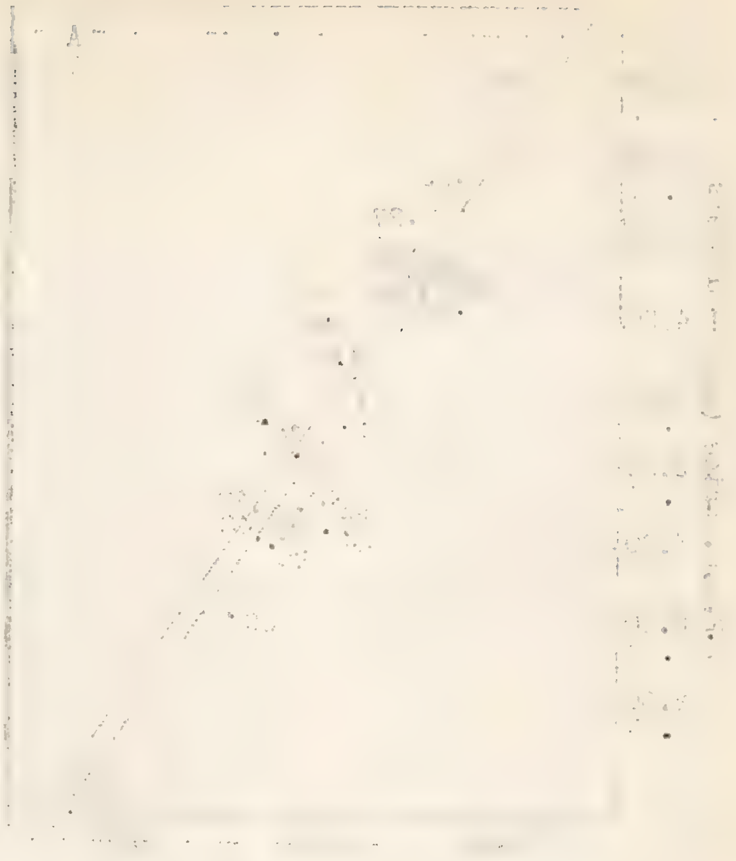


Fig. 5.-- Summer lemons: Net regressions of price on (A) per capita United States supply ($x'_{12^o} = 13.0064 - 3.6617\ x^o_2$), (B) index of per capita nonagricultural income payments ($x'_{13^o} = -0.8778 + 0.565\ x^o_3$), and (C) index of temperature ($x'_{14} = 0.9706 + 0.0272\ x_4$), 1922-1941. Arithmetic form.



[illegible]



[illegible]

[illegible]

[illegible]

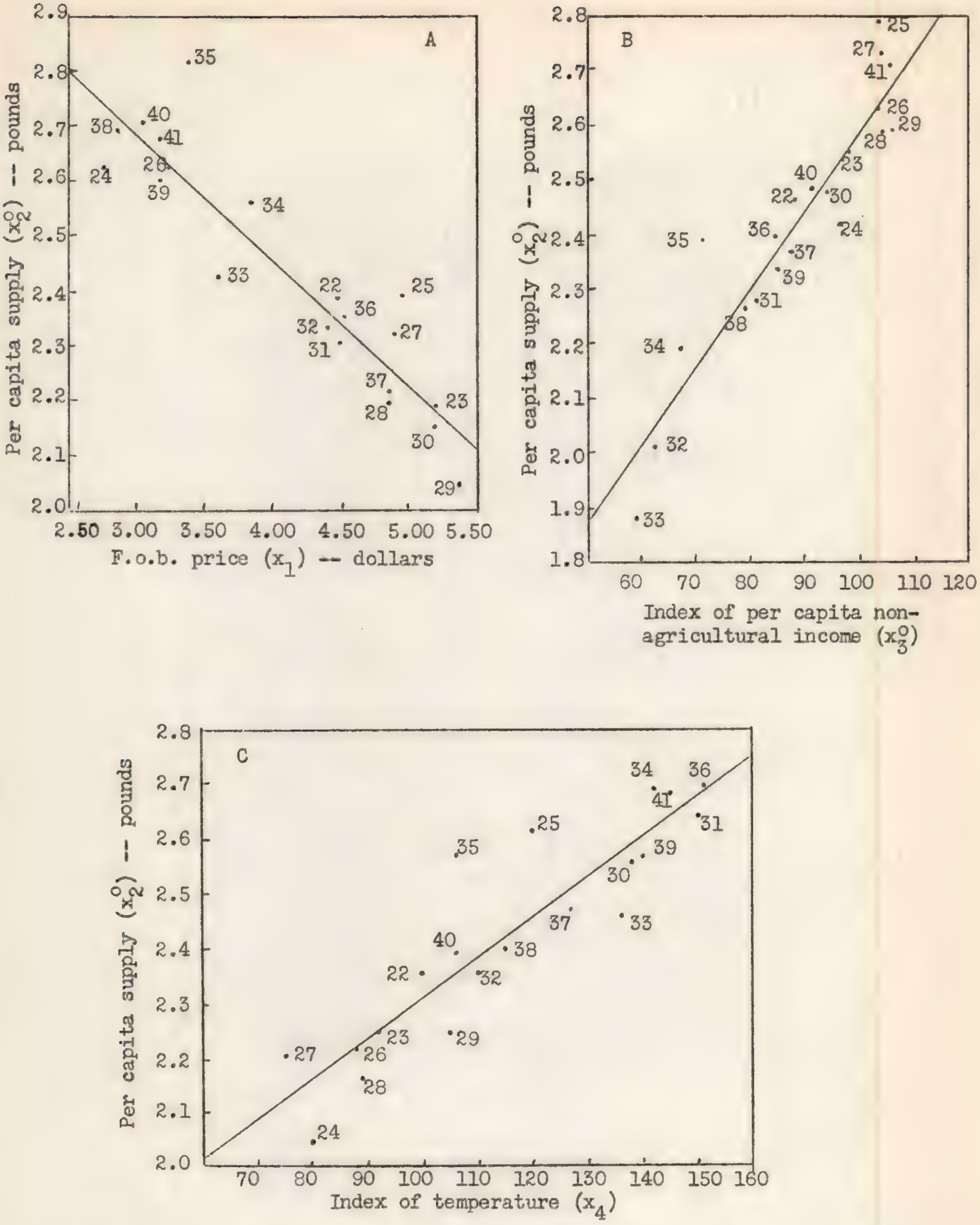


Fig. 6.-- Summer lemons: Net regressions of per capita United States supply on (A) price ($x^o_{21} = 3.3727 - 0.2295\, x_1$), (B) index of per capita nonagricultural income payments ($x^o_{23} = 1.1373 + 0.0146\, x^o_3$), and (C) index of temperature ($x^o_{24} = 1.5884 + 0.0073\, x_4$), 1922-1941. Arithmetic form.

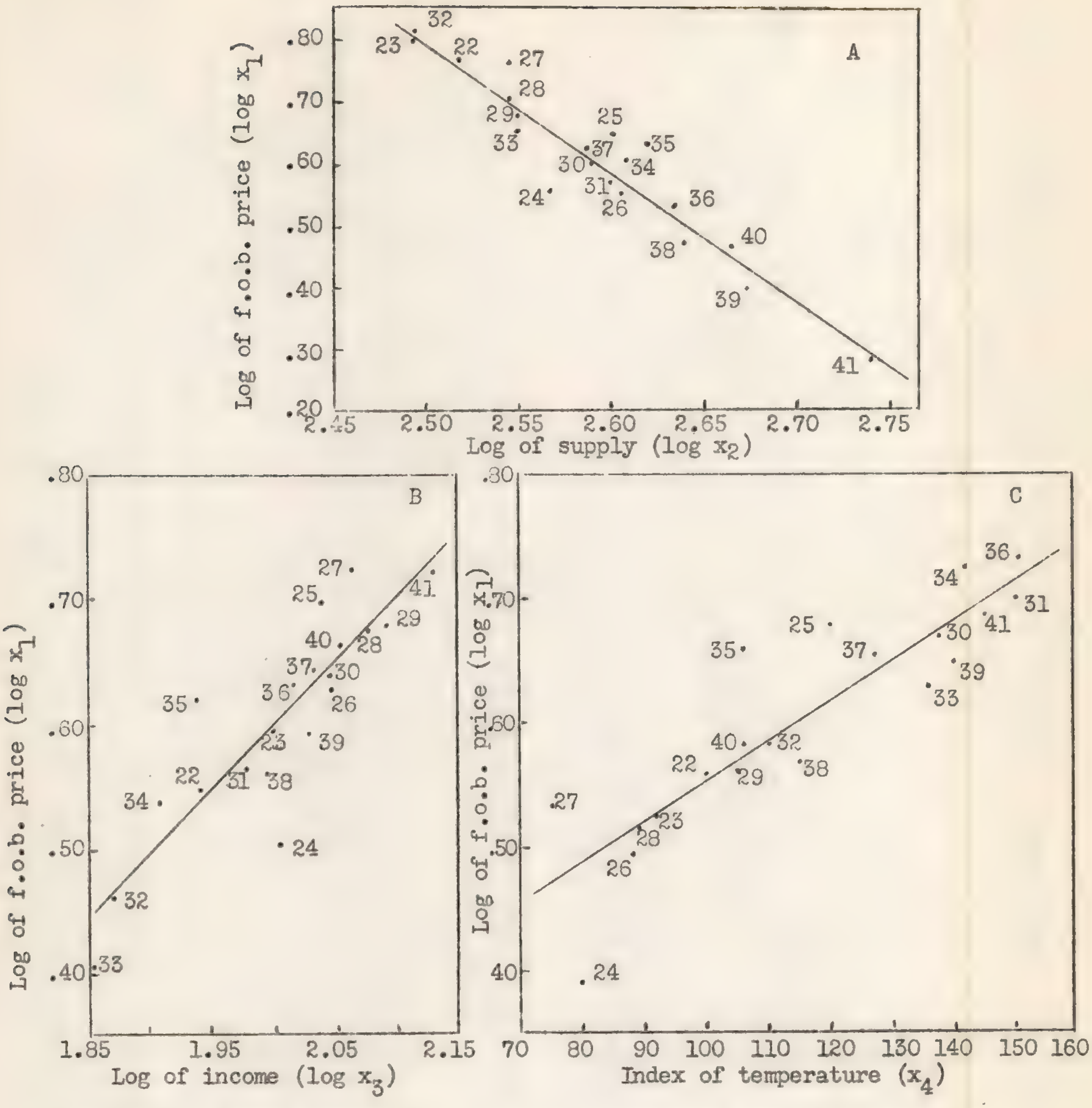


Fig. 7.-- Summer lemons: Net regressions of price on (A) United States supply (log $x'_{12}$ = 6.0076 - 2.0854 log $x_2$), (B) index of nonagricultural income payments (log $x'_{13}$ = -1.4737 + 1.0356 log $x_3$), and (C) index of temperature (log $x'_{14}$ = 0.2300 + 0.0032 $x_4$), 1922-1941. Logarithmic form.

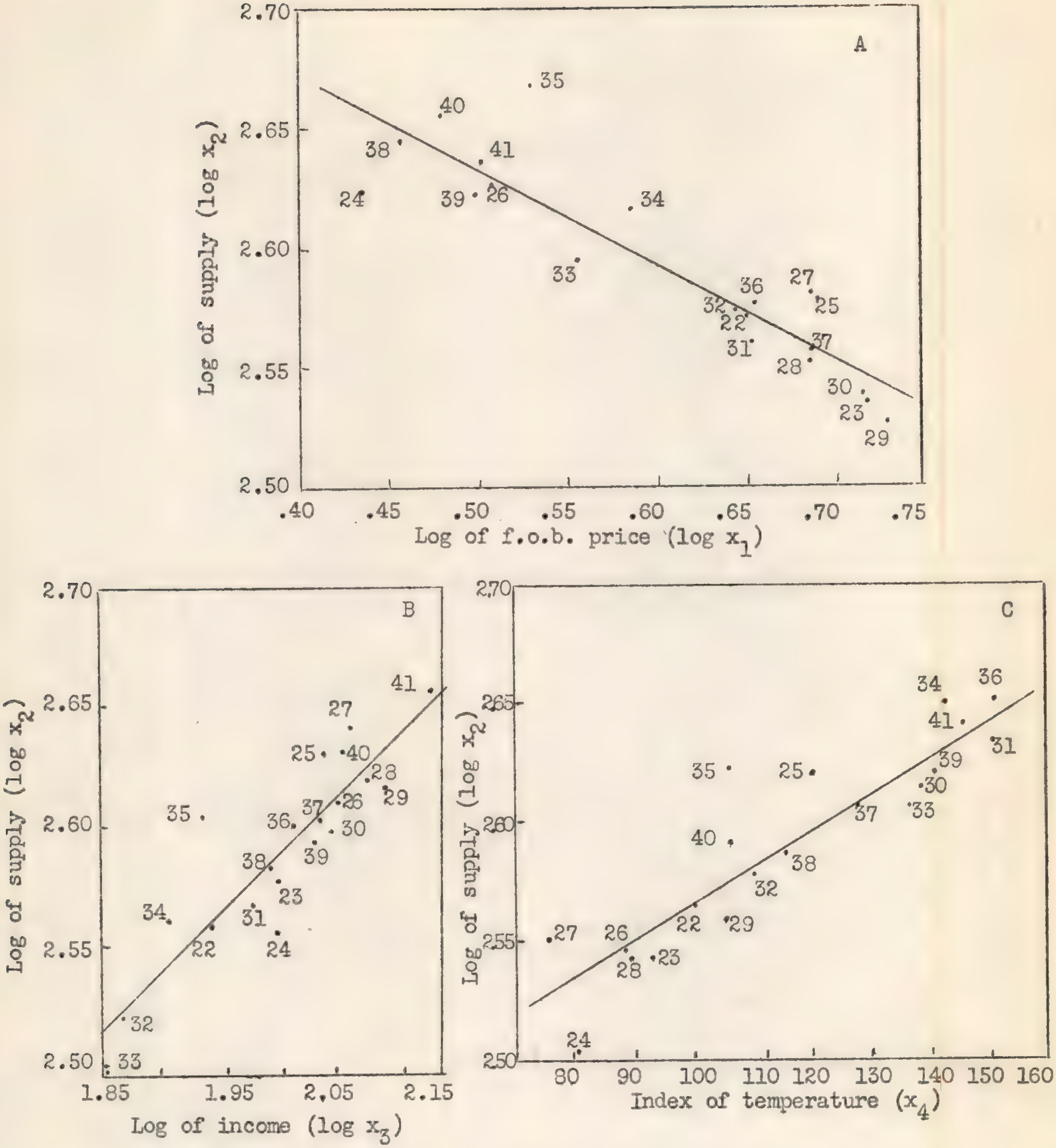


Fig. 8.-- Summer lemons: Net regressions of United States supply on (A) price ($\log x'_{21} = 2.8306 - 0.3965 \log x_1$), (B) index of nonagricultural income payments ($\log x'_{23} = 1.6148 + 0.4865 \log x_3$), and (C) index of temperature ($\log x'_{24} = 2.4123 + 0.0015\, x_4$), 1922-1941. Logarithmic form.

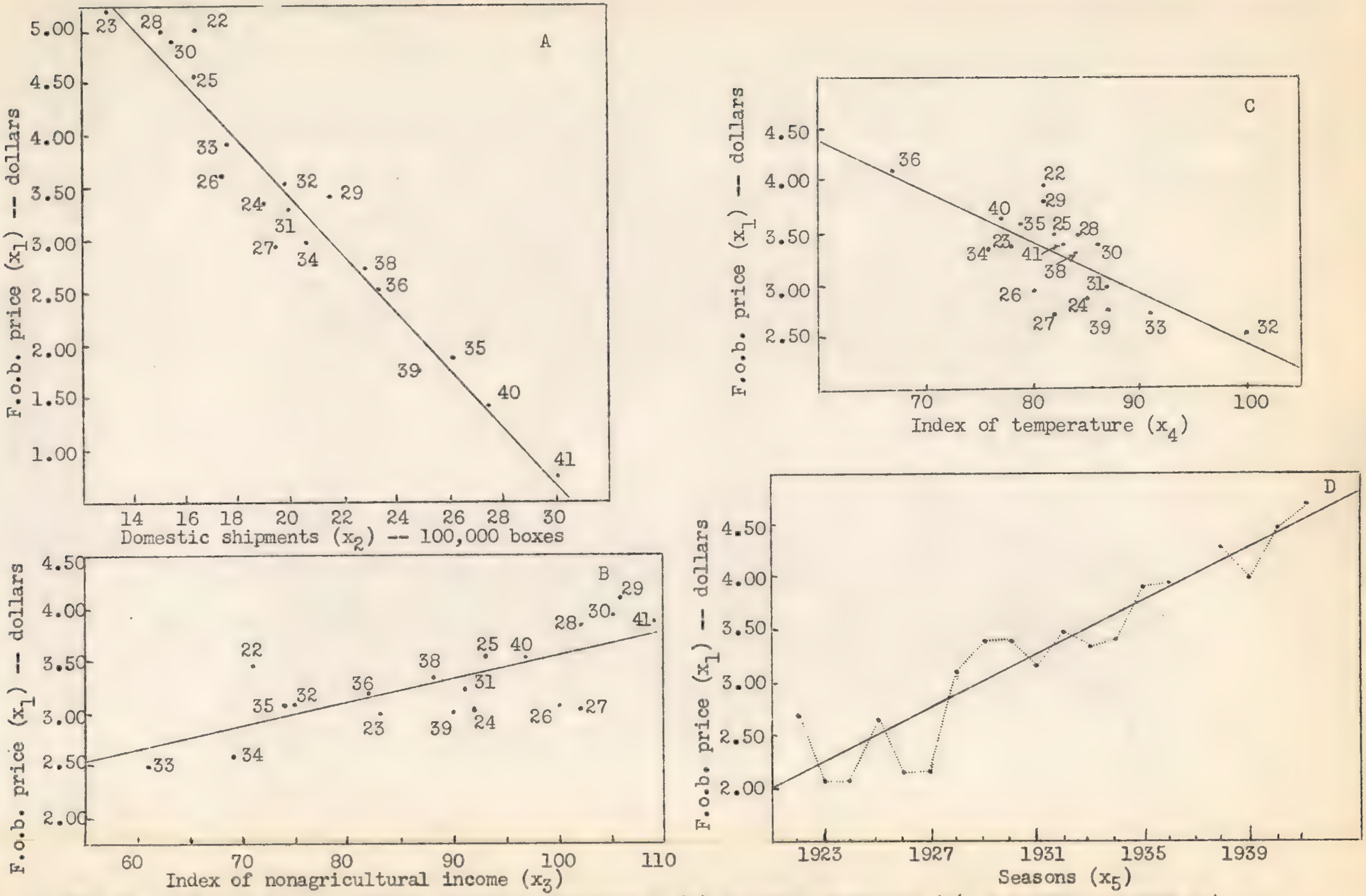


Fig. 9.-- Winter lemons: Net regressions of price on (A) domestic shipments ($x'_{12} = 8.9058 - 0.0028\ x_2$), (B) index of nonagricultural income payments ($x'_{13} = 1.2950 + 0.0225\ x_3$), (C) index of temperature ($x'_{14} = 7.2948 - 0.0484\ x_4$), and (D) time ($x'_{15} = 3.3295 + 0.0636\ x_5$), 1921-22 to 1940-41. Arithmetic form.

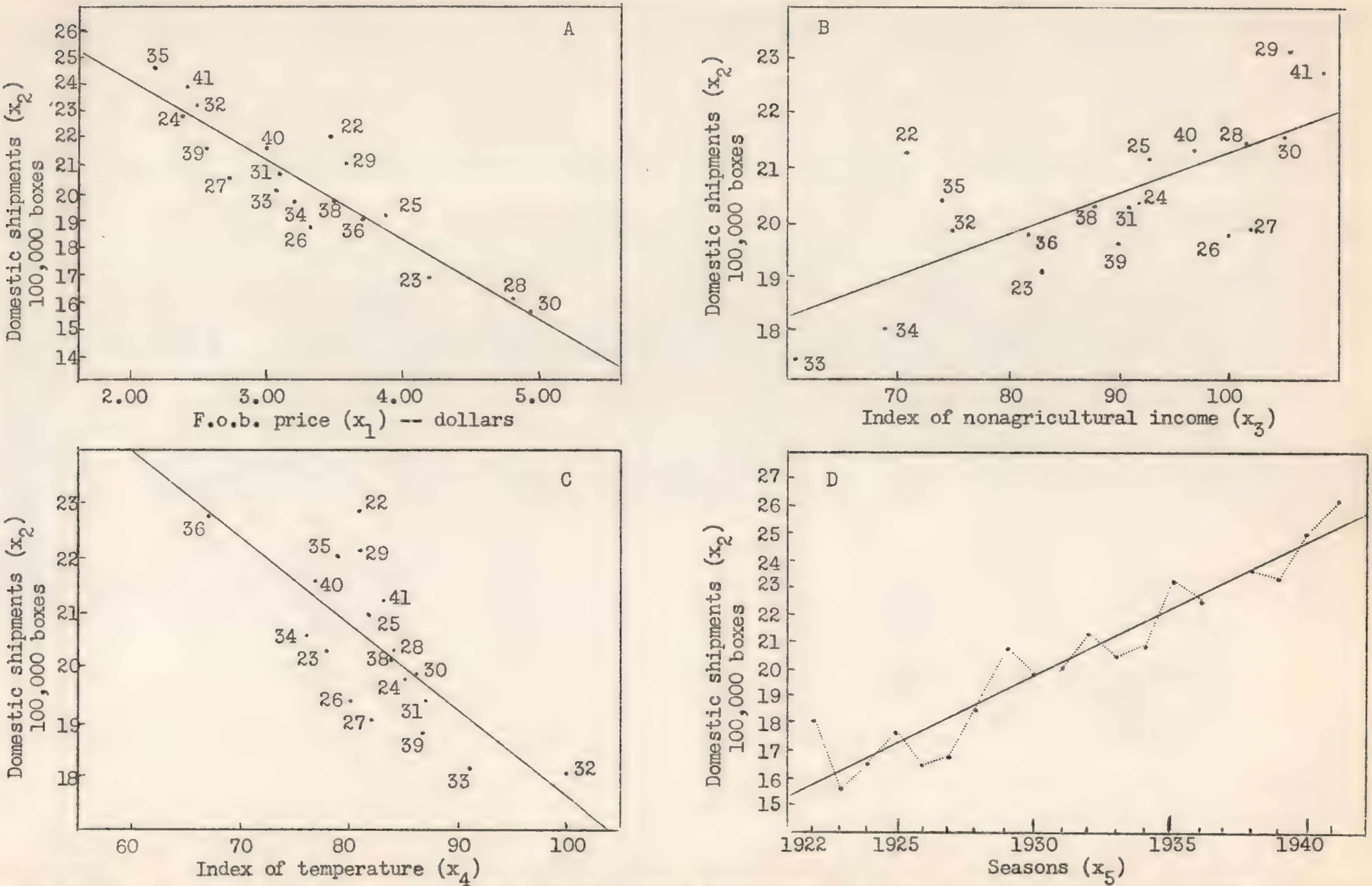
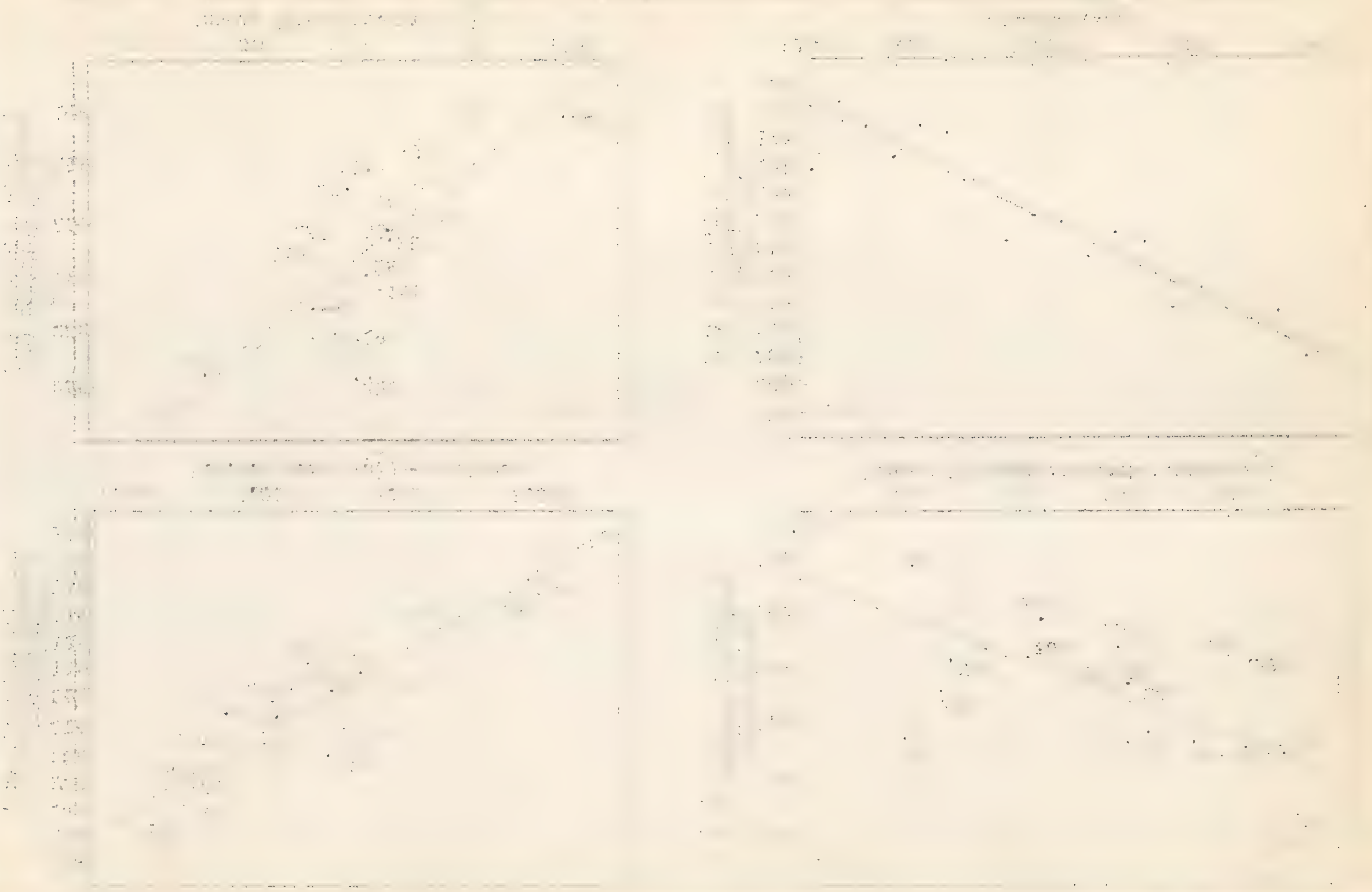


Fig. 10.-- Winter lemons: Net regressions of domestic shipments on (A) price ($x'_{21} = 3{,}010.03 - 294.93\ x_1$), (B) index of nonagricultural income payments ($x'_{23} = 1{,}388.5 + 7.3125\ x_3$), (C) index of temperature ($x'_{24} = 3{,}355.1 - 15.927\ x_4$), and (D) time ($x'_{25} = 2{,}053.3 + 24.805\ x_5$), 1921-22 to 1940-41. Arithmetic form.



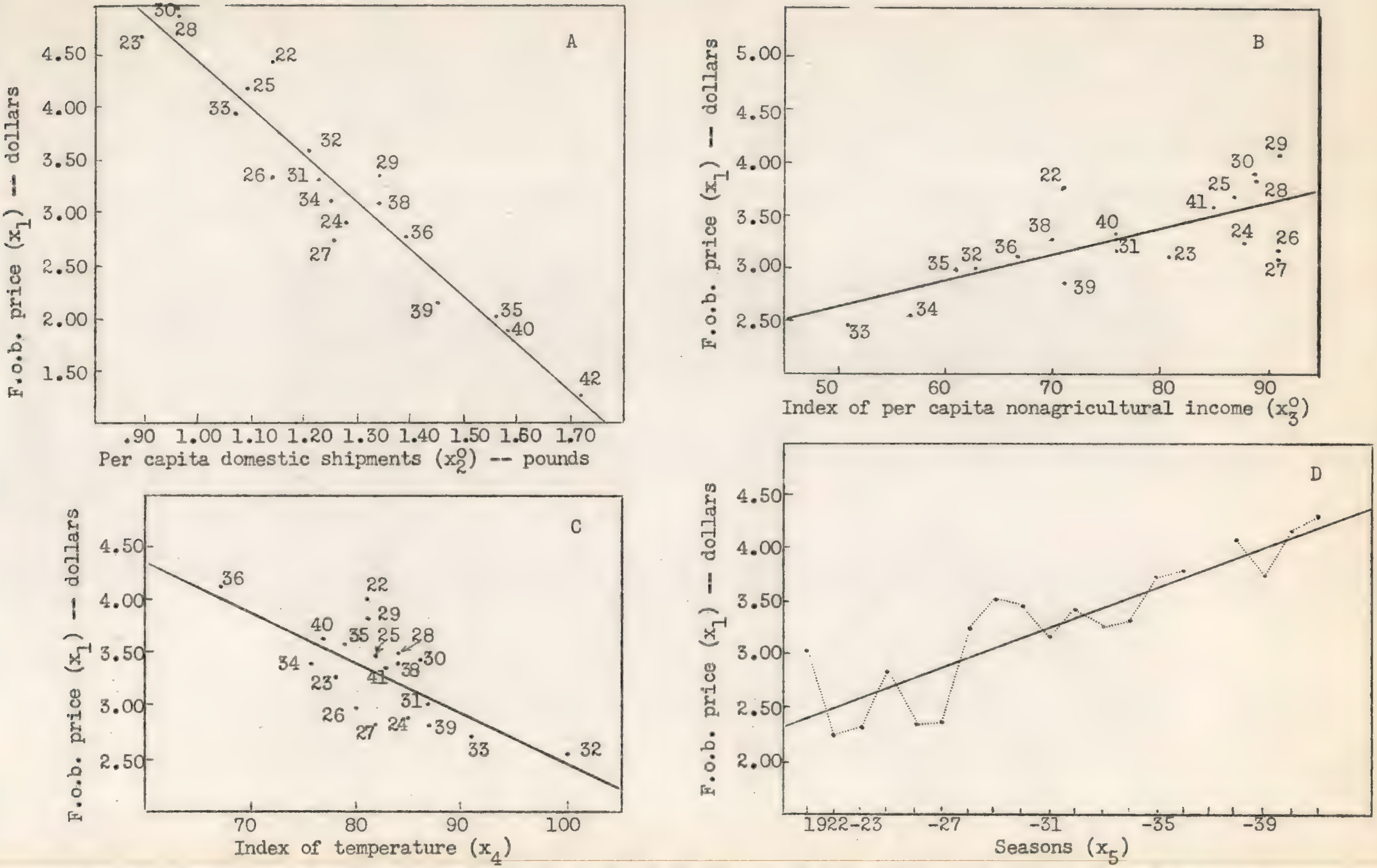


Fig. 11.-- Winter lemons: Net regressions of price on (A) per capita domestic shipments ($x'_{12o}$ = 8.9028 - 4.4674 $x_2^o$), (B) index of per capita nonagricultural income payments ($x'_{13o}$ = 1.4173 + 0.0245 $x_3^o$), (C) index of temperature ($x'_{14}$ = 7.2061 - 0.0474 $x_4$), and (D) time ($x'_{15}$ = 3.3204 + 0.0479 $x_5$), 1921-22 to 1940-41. Arithmetic form.

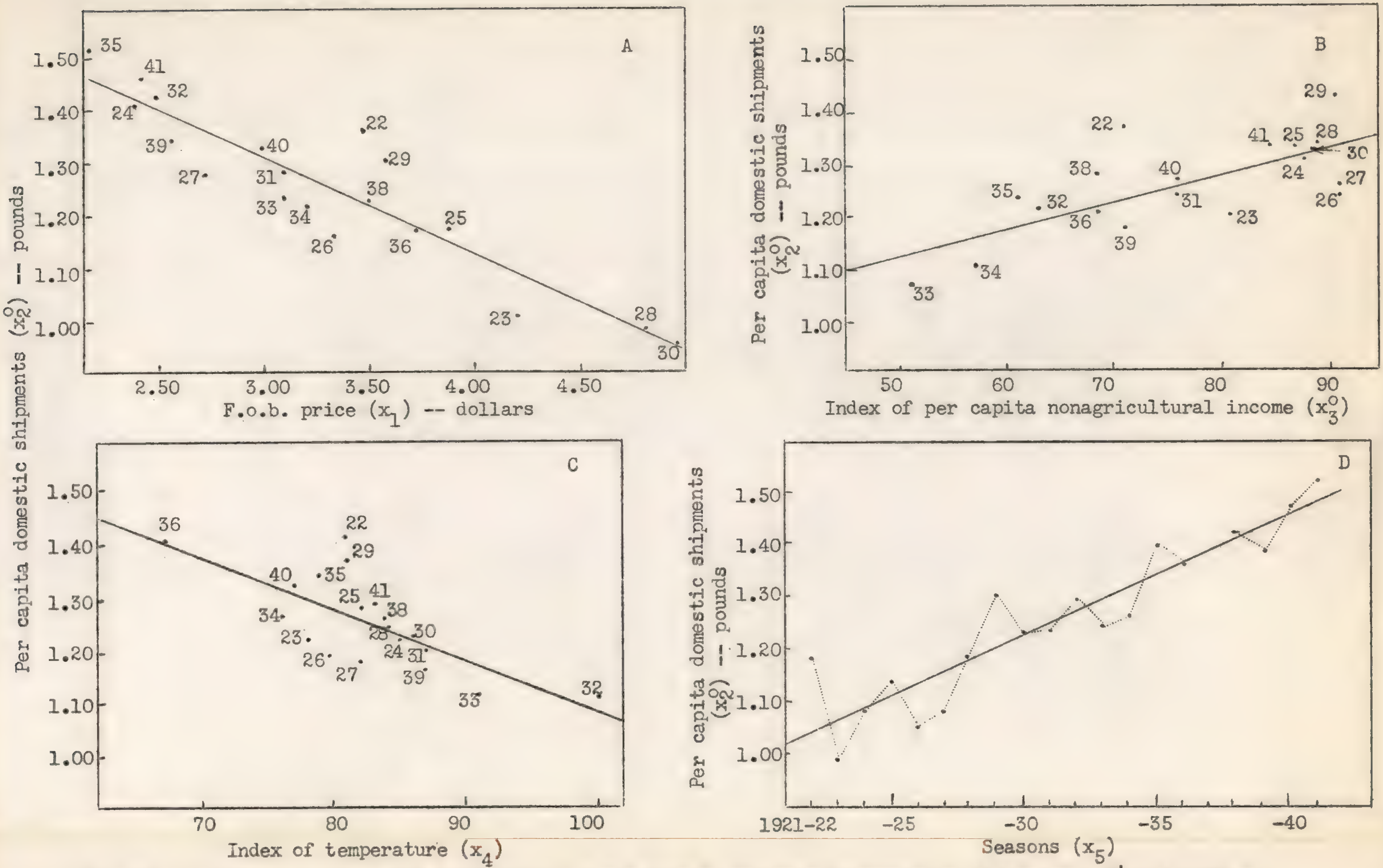


Fig. 12.-- Winter lemons: Net regressions of per capita domestic shipments on (A) price ($x_{21}^{o'}$ = 1.8569 - 0.1825 $x_1$), (B) index of per capita nonagricultural income payments ($x_{23o}^{o'}$ = 0.8746 + 0.0050 $x_3^o$), (C) index of temperature ($x_{24}^{o'}$ = 2.0503 - 0.0096 $x_4$), and (D) time ($x_{25}^{o'}$ = 1.2625 + 0.0115 $x_5$), 1921-22 to 1940-41. Arithmetic form.

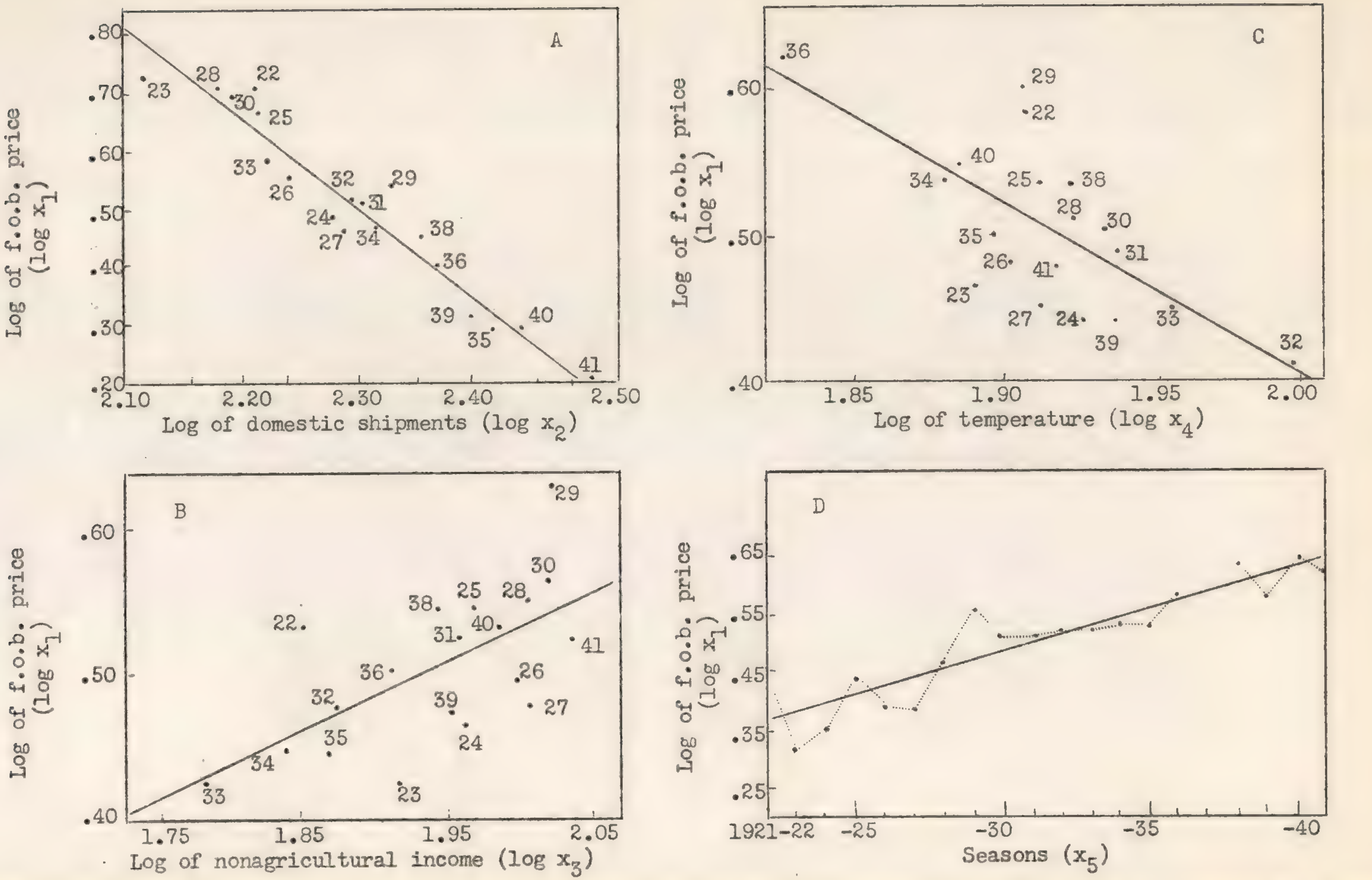
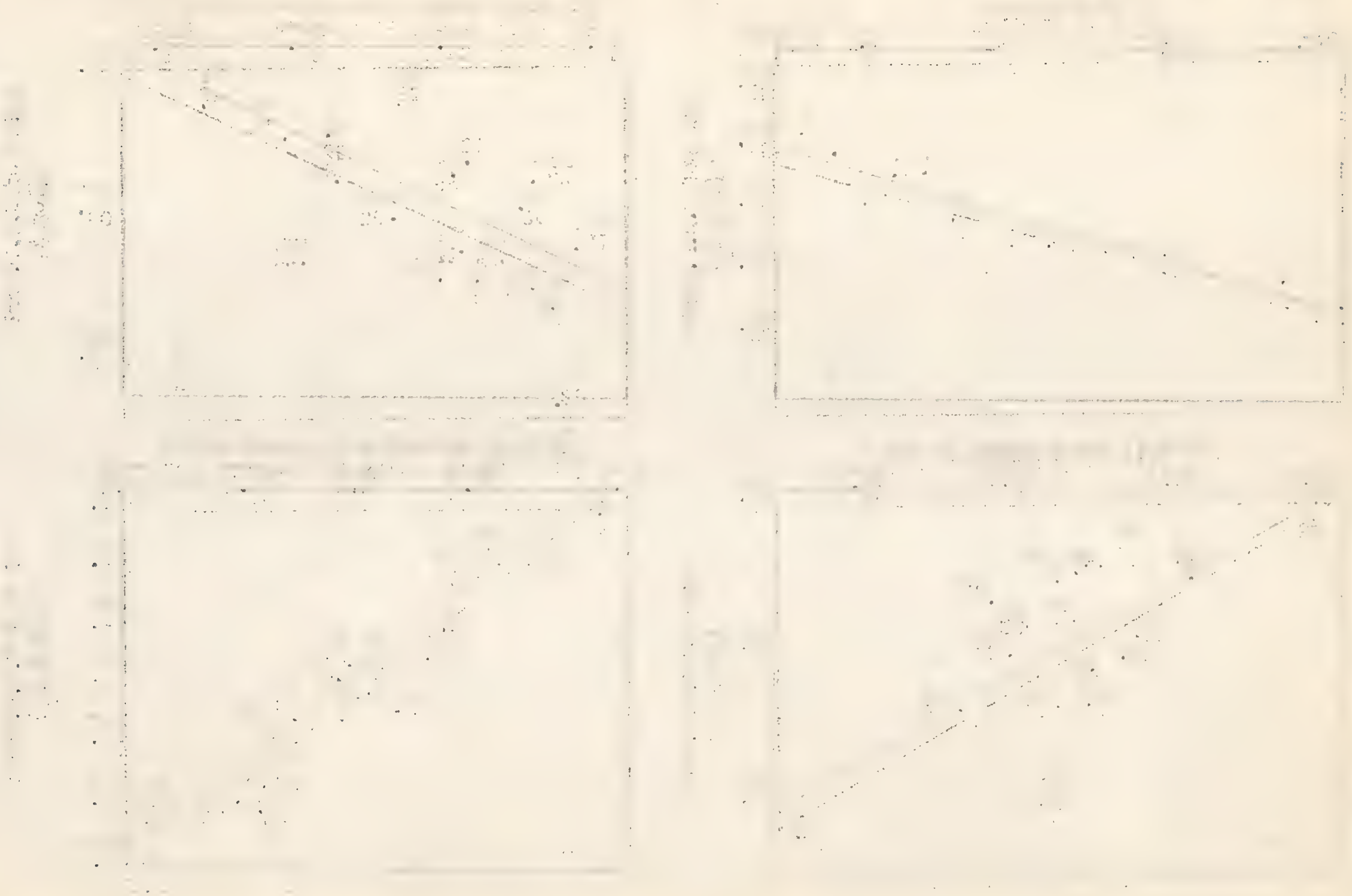


Fig. 13-- Winter lemons: Net regressions of price on (A) domestic shipments ($\log x'_{12} = 4.1432 - 1.5816 \log x_2$), (B) index of nonagricultural income payments ($\log x'_{13} = -0.3898 + 0.4610 \log x_3$), (C) index of temperature ($\log x'_{14} = 2.7348 - 1.1632 \log x_4$), and (D) time ($\log x'_{15} = 0.5105 + 0.0073\, x_5$), 1921-22 to 1940-41. Logarithmic form.

[illegible]



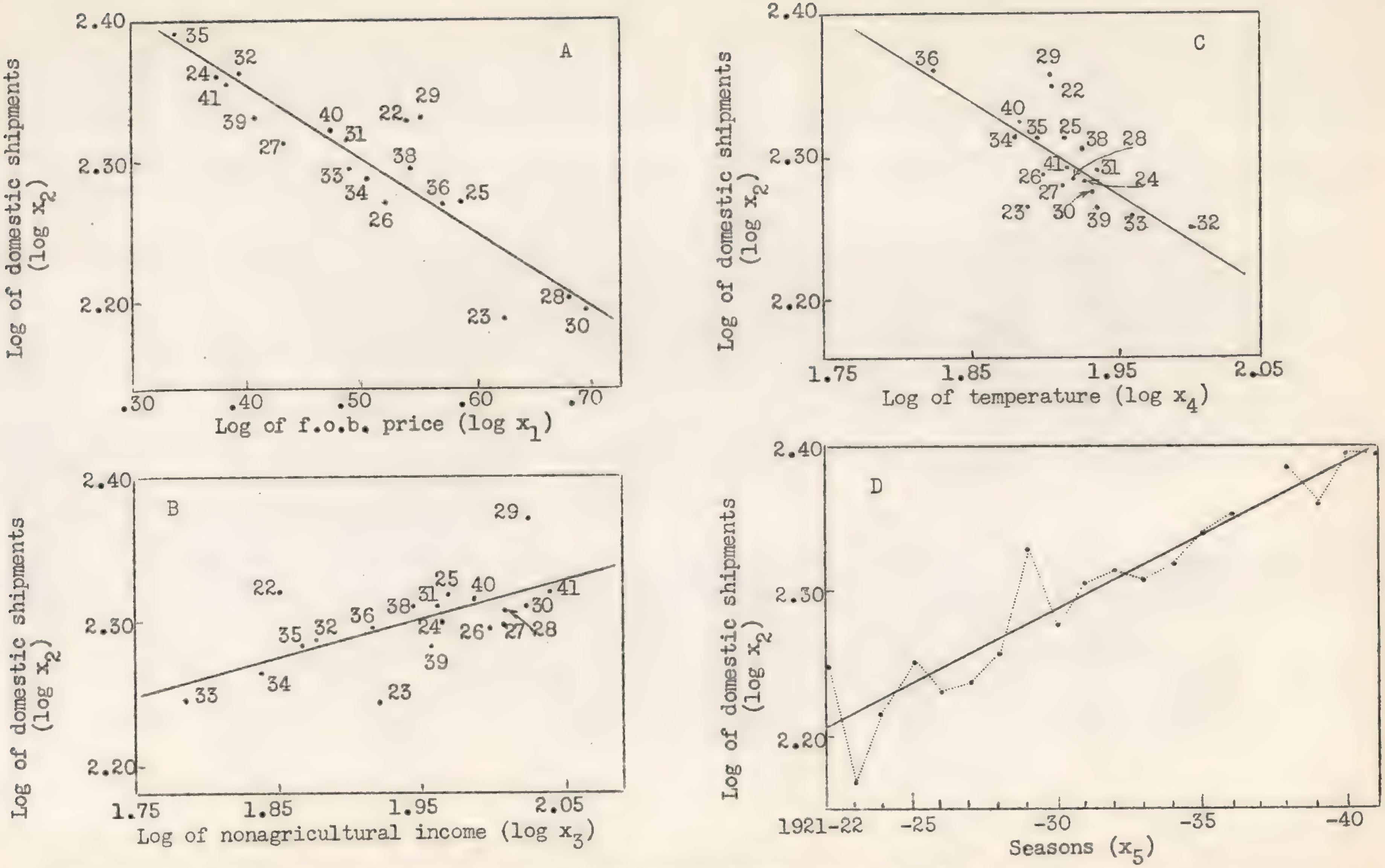
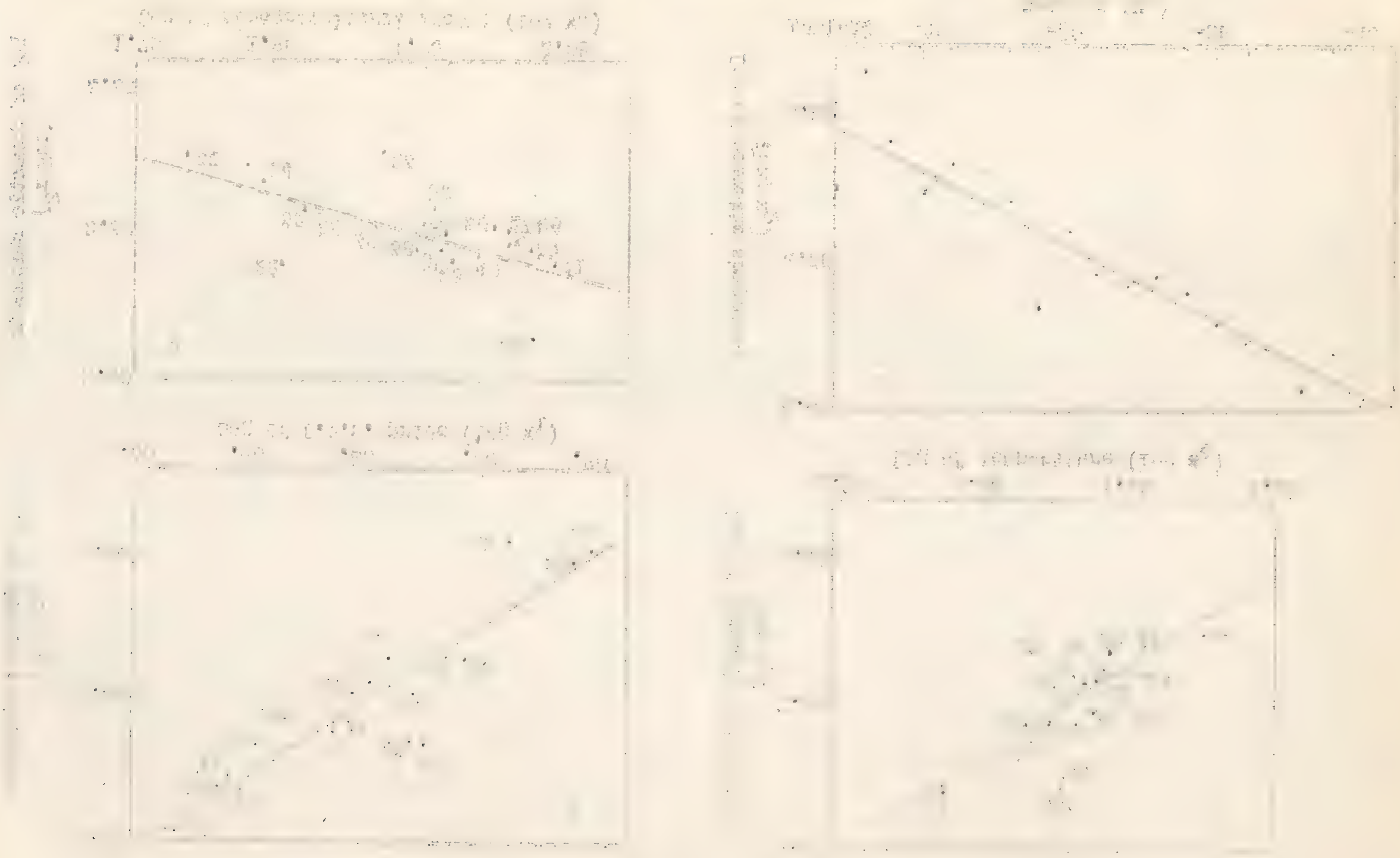


Fig. 14.-- Winter lemons: Net regressions of domestic shipments on (A) price (log $x'_{21}$ = 2.5518 - 0.4984 log $x_1$), (B) index of nonagricultural income payments (log $x'_{23}$ = 1.8008 + 0.2566 log $x_3$), (C) index of temperature log $x'_{24}$ = 3.5279 - 0.6412 log $x_4$), and (D) time (log $x'_{25}$ = 2.3024 + 0.0051 $x_5$), 1921-22 to 1940-41. Logarithmic form.

[illegible]



# APPENDIX D

## Auxiliary Tables

## TABLE 30

### Winter Lemons: The Effect of Adjusting Domestic Shipments in 1936-37 on the Net Regression Coefficients and on the Coefficients of Multiple Correlation

| Equation | Dependent variable | Net regression coefficients * | | | | | Adjusted coefficient of multiple correlation |
|---|---|---|---|---|---|---|---|
| | | F.o.b. price | Domestic shipments | Nonagricultural income | Index of temperatures | Time | |
| | $F(x)$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $\bar{R}$ |
| Including 1936-37, not adjusted | $x_1$ | | -0.0027<br>(0.0005) | 0.0232<br>(0.0082) | -0.0352<br>(0.0176 | 0.0652<br>(0.0191) | 0.7867 |
| | $x_2$ | -240.5343<br>(46.5887) | | 6.8369<br>(2.5069) | -12.9784<br>(4.9377) | 27.3906<br>(2.9472) | 0.9494 |
| Adjusting 1936-37 shipment observation to 2,204,000 boxes | $x_1$ | | -0.0028<br>(0.0004) | 0.0233<br>(0.0060) | -0.0451<br>(0.0124) | 0.0677<br>(0.0131) | 0.8941 |
| | $x_2$ | -285.5297<br>(36.2236) | | 7.3266<br>(1.9156) | -14.8370<br>(3.8206) | 25.4577<br>(2.2611) | 0.9686 |

* $x_1$ = Seasonal average f.o.b. price in dollars per box.

$x_2$ = Domestic shipments of California and Arizona lemons in units of 1,000 boxes.

$x_3$ = Index of nonagricultural income payments, 1924-25 to 1928-29 = 100.

$x_4$ = Index of mean temperatures in December, January, and February in 32 metropolitan districts, 1931-32 = 100.

$x_5$ = Time in units of half years, origin halfway between 1930-31 and 1931-32.

## TABLE 31

Summer Lemons: Intercorrelations of the Series Employed in the Regression Analyses

| | $x_1$ | $x_2$ | $x_2^o$ | $x_3$ | $x_3^o$ | $x_4$ | $x_{2d}$ | $x_{2i}$ | $x_{2e}$ | $x_{2o}$ | log $x_1$ | log $x_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $x_2$ | -0.572288 | 1 | | | | | | | | | | |
| $x_2^o$ | -0.548529 | | 1 | | | | | | | | | |
| $x_3$ | 0.118360 | 0.452897 | | 1 | | | | | | | | |
| $x_3^o$ | 0.272808 | | 0.331642 | | 1 | | | | | | | |
| $x_4$ | -0.026852 | 0.514790 | 0.347067 | -0.130167 | -0.405177 | 1 | | | | | | |
| $x_{2d}$ | -0.606340 | | | 0.236590 | | 0.592982 | 1 | | | | | |
| $x_{2i}$ | 0.469018 | | | 0.160461 | | -0.519741 | -0.807169 | 1 | | | | |
| $x_{2e}$ | -0.562579 | | | 0.248953 | | 0.613403 | | | 1 | | | |
| $x_{2o}$ | 0.343487 | | | 0.157795 | | -0.543965 | | | -0.772969 | 1 | | |
| log $x_1$ | | | | | | 0.005085 | | | | | 1 | |
| log $x_2$ | | | | | | 0.520499 | | | | | -0.570926 | 1 |
| log $x_3$ | | | | | | -0.144313 | | | | | 0.088095 | 0.430650 |

$x_1$ = Seasonal average f.o.b. price of summer lemons.

$x_2$ = United States supply of summer lemons.

$x_2^o$ = Per capita United States supply of summer lemons.

$x_3$ = Index of nonagricultural income.

$x_3^o$ = Index of per capita nonagricultural income.

$x_4$ = Index of temperature.

$x_{2d}$ = Domestic shipments of summer lemons.

$x_{2i}$ = Imports of summer lemons for consumption.

$x_{2e}$ = Domestic shipments of summer lemons by California Fruit Growers Exchange.

$x_{2o}$ = Domestic shipments of summer lemons outside California Fruit Growers Exchange plus imports of summer lemons for consumption.

## TABLE 32

### Summer Lemons: Reciprocal Correlation Matrices

| | Equations 1s and 2s | | | |
|---|---|---|---|---|
| | $x_1$ | $x_2$ | $x_3$ | $x_4$ |
| $x_1$ | 6.562543 | | | |
| $x_2$ | 8.833359 | 14.063709 | | |
| $x_3$ | -5.438465 | -8.469953 | 6.132164 | |
| $x_4$ | -5.079015 | -8.105168 | 5.012417 | 5.688528 |

| | Equations 3s and 4s | | | |
|---|---|---|---|---|
| | $x_1$ | $x_2^o$ | $x_3^o$ | $x_4$ |
| $x_1$ | 6.829170 | | | |
| $x_2^o$ | 7.659574 | 10.223064 | | |
| $x_3^o$ | -6.467930 | -8.176593 | 7.843269 | |
| $x_4$ | -5.095665 | -6.655381 | 5.842061 | 5.540103 |

| | Equations 5s and 6s | | | |
|---|---|---|---|---|
| | $\log x_1$ | $\log x_2$ | $\log x_3$ | $x_4$ |
| $\log x_1$ | 5.823581 | | | |
| $\log x_2$ | 7.710820 | 12.347127 | | |
| $\log x_3$ | -4.511113 | -7.077073 | 5.085974 | |
| $x_4$ | -4.694097 | -7.487188 | 4.440520 | 5.561766 |

| | Equations 6s and 7s | | | | |
|---|---|---|---|---|---|
| | $x_1$ | $x_{2d}$ | $x_{2i}$ | $x_3$ | $x_4$ |
| $x_1$ | 6.808934 | | | | |
| $x_{2d}$ | 12.769370 | 30.168585 | | | |
| $x_{2i}$ | 5.165902 | 14.248319 | 8.648916 | | |
| $x_3$ | -5.359076 | -12.466534 | -5.967977 | 6.185965 | |
| $x_4$ | -5.401821 | -11.763851 | -4.591926 | 4.951939 | 6.088672 |

| | Equations 8s and 9s | | | | |
|---|---|---|---|---|---|
| | $x_1$ | $x_{2e}$ | $x_{2o}$ | $x_3$ | $x_4$ |
| $x_1$ | 6.643819 | | | | |
| $x_{2e}$ | 12.375084 | 28.082392 | | | |
| $x_{2e}$ | 5.282716 | 13.224280 | 7.912748 | | |
| $x_3$ | -5.382782 | -12.008727 | -5.740498 | 6.170648 | |
| $x_4$ | -5.239562 | -11.263123 | -4.412927 | 4.902235 | 6.005772 |

For the meaning of the various x's, see table 31.

## TABLE 33

### Winter Lemons: Intercorrelations of the Series Employed in the Regression Analyses

| | $x_1$ | $x_2$ | $x_2^o$ | $x_3$ | $x_3^o$ | $x_4$ | $x_5$ | log $x_1$ | log $x_2$ | log $x_3$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $x_2$ | -0.645360 | 1 | | | | | | | | |
| $x_2^o$ | -0.710609 | | 1 | | | | | | | |
| $x_3$ | 0.234004 | 0.133383 | | 1 | | | | | | |
| $x_3^o$ | 0.340976 | | -0.169203 | | 1 | | | | | |
| $x_4$ | -0.209951 | -0.174066 | -0.207373 | -0.082620 | -0.095509 | 1 | | | | |
| $x_5$ | -0.363738 | 0.849398 | 0.740809 | 0.011540 | -0.427189 | -0.042935 | 1 | | | |
| log $x_1$ | | | | | | | -0.367142 | 1 | | |
| log $x_2$ | | | | | | | 0.840508 | -0.666677 | 1 | |
| log $x_3$ | | | | | | | 0.003982 | 0.201064 | 0.106258 | 1 |
| log $x_4$ | | | | | | | -0.059772 | -0.234293 | -0.163422 | -0.071114 |

$x_1$ = Seasonal average f.o.b. price of winter lemons.
$x_2$ = Domestic shipments of winter lemons.
$x_2^o$ = Per capita domestic shipments of winter lemons.
$x_3$ = Index of nonagricultural income.
$x_3^o$ = Index of per capita nonagricultural income.
$x_4$ = Index of temperature.
$x_5$ = Time.

## TABLE 34

### Winter Lemons: Reciprocal Correlation Matrices

| | Equations 1w and 2w | | | | |
|---|---|---|---|---|---|
| | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ |
| $x_1$ | 6.913313 | | | | |
| $x_2$ | 10.986835 | 21.511390 | | | |
| $x_3$ | -2.770949 | -4.861574 | 2.169333 | | |
| $x_4$ | 2.848864 | 5.048229 | -1.117880 | 2.249574 | |
| $x_5$ | -6.663260 | -14.002538 | 3.048479 | -3.142227 | 10.299944 |

| | Equations 3w and 4w | | | | |
|---|---|---|---|---|---|
| | $x_1$ | $x_2^o$ | $x_3^o$ | $x_4$ | $x_5$ |
| $x_1$ | 6.905547 | | | | |
| $x_2^o$ | 8.734010 | 13.545363 | | | |
| $x_3^o$ | -2.753762 | -3.878092 | 2.403604 | | |
| $x_4$ | 2.782599 | 3.913811 | -1.030239 | 2.201530 | |
| $x_5$ | -5.015852 | -8.346937 | 2.854046 | -2.233046 | 6,482752 |

| | Equations 5w and 6w | | | | |
|---|---|---|---|---|---|
| | log $x_1$ | log $x_2$ | log $x_3$ | log $x_4$ | $x_5$ |
| log $x_1$ | 6.171160 | | | | |
| log $x_2$ | 9.195382 | 17.382883 | | | |
| log $x_3$ | -2.019832 | -3.360642 | 1.699643 | | |
| log $x_4$ | 2.487777 | 4.100113 | -0.780249 | 2.053562 | |
| $x_5$ | -5.306360 | -10.975990 | 2.029677 | -2.406959 | 8.125271 |

For the meaning of the various x's, see table 33.

# APPENDIX E

## The Use of Mean Monthly Maximum Temperatures in the Summer Lemons Regression Analysis

The chief drawback of the index of summer temperatures described in appendix A is that it is laborious to calculate. In this appendix are reported the results secured with the use of another temperature variable (see table 35), the extension of which to future seasons is relatively easy. This series consists of monthly mean maximum temperatures, May through September, in 22 cities weighted by 1931-38 average unloads of lemons in these cities for corresponding months.[55] The weights used are given in table 36. While less sensitive than the index described in appendix A, this temperature variable yields quite similar results in the seasonal analysis.

In table 37 are given the regression coefficients and auxiliary constants obtained when mean maximum temperatures were used in place of the index of summer temperatures described previously. The other variables in the two equations presented in table 37 are those used in equations 1s and 2s of table 3. It is seen that with f.o.b. price as dependent variable, the adjusted coefficient of multiple correlation is of the same magnitude as that corresponding to equation 1s (0.9031 as against 0.9050 secured with equation 1s). With the United States supply as dependent variable, the adjusted coefficient of multiple correlation is somewhat lower than the coefficient of equation 2s (0.9482 as against 0.9569), but the difference between them is not large. The magnitudes of the regression coefficients of these equations differ somewhat from those of comparable coefficients of equations 1s and 2s, but here, too, the discrepancies are not large. It is clear from the foregoing that the equations described in table 37 are acceptable substitutes

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[55] Wellman, H. R. Statistics pertaining to lemons. California Agr. Exp. Sta. October, 1940. (Processed).

for equations 1s and 2s presented in the text.

In table 37 are also indicated the coefficients of separate determination pertaining to the two equations. It is seen that the bulk of the variation of f.o.b. price is attributable to variation in the United States supply, and that income, and especially temperature, are relatively unimportant. These results are similar to those secured with equation 1s, and it is thus evident that the minor role played by temperature, as indicated by coefficients of separate determination, is not a consequence of the idiosyncracies of the index of summer temperatures described in appendix A. But here also it should be observed that from the point of view of goodness of fit, temperature is an important and, in fact, an indispensable independent variable, since its omission results in a marked lowering of the fit of both equations. [56]

One other point should be mentioned, namely, that the introduction of "time" as an additional independent variable does not improve significantly the fit of these equations. The ratios of the net regression coefficients of the added variable "time" to their standard errors are .329 and 1.846 respectively with f.o.b. price and United States supply as the dependent variable. The null hypothesis here cannot be rejected since for 15 degrees of freedom the t-ratio at the 5 per cent level is 2.131. The explanation of the failure of "time" to contribute significantly, advanced in the text in connection with equations 1s and 2s, is applicable here, for mean maximum temperatures also exhibit an upward trend during the period under review. [57]

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[56] The coefficients of multiple correlation with f.o.b. price as the dependent variable obtained when United States supply, index of nonagricultural income, and the temperature variable are omitted in turn are $R_{1(34^{o})} = 0.1416$, $\bar{R}_{1(24^{o})} = 0.5627$, $\bar{R}_{1(23)} = 0.6699$. The first multiple correlation coefficient was not adjusted because the adjustment resulted in an imaginary value of the coefficient.

[57] The equation of the trend in mean maximum temperatures is:

$$x_4^{o\prime} = 79.5950 + 0.0683\, x_5$$

where $x_5$ is time measured in half-years with the origin half-way between 1931 and 1932. The standard error of the coefficient of $x_5$ is 0.0276 yielding $t = 2.478$. For 18 degrees of freedom the t-ratio at the 5 per cent level is 2.101.

## TABLE 35

### Mean Maximum Temperatures in 22 Cities

### May-September, 1922 to 1941

| Year May-September | Mean maximum temperatures | Year May-September | Mean maximum temperatures |
|---|---|---|---|
| | degrees | | degrees |
| 1922 | 79.5 | 1932 | 80.2 |
| 1923 | 79.0 | 1933 | 81.1 |
| 1924 | 76.6 | 1934 | 82.3 |
| 1925 | 79.9 | 1935 | 78.7 |
| 1926 | 77.8 | 1936 | 81.4 |
| 1927 | 76.6 | 1937 | 80.1 |
| 1928 | 77.6 | 1938 | 79.8 |
| 1929 | 78.7 | 1939 | 80.9 |
| 1930 | 81.2 | 1940 | 78.8 |
| 1931 | 80.7 | 1941 | 81.0 |

Source of data:

Wellman, H. R. Statistics pertaining to lemons. California Agr. Exp. Sta. October, 1940. (Processed). Extended through 1941. The entries are monthly mean maximum temperatures May through September in 22 cities weighted by 1931-38 average unloads of lemons for corresponding months. For cities included see table 36.

TABLE 36

Average Rail and Boat Unloads of Lemons in May, June, July, August and September in 22 Cities, 1931 to 1938

| Cities | Average unloads | | | | |
|---|---|---|---|---|---|
| | May | June | July | August | September |
| | Carlots | | | | |
| Atlanta, Ga. | 25.1 | 34.4 | 25.6 | 24.4 | 18.6 |
| Baltimore, Md. | 49.1 | 95.1 | 100.4 | 69.9 | 32.0 |
| Boston, Mass. | 63.9 | 88.9 | 99.1 | 74.7 | 35.5 |
| Buffalo, N. Y. | 19.4 | 26.4 | 19.4 | 18.5 | 9.5 |
| Chicago, Ill. | 114.9 | 164.5 | 191.8 | 129.5 | 74.0 |
| Cincinnati, Ohio | 44.4 | 81.2 | 86.7 | 55.9 | 29.8 |
| Cleveland, Ohio | 47.4 | 65.4 | 58.6 | 40.1 | 22.1 |
| Dallas, Texas | 20.5 | 21.4 | 19.7 | 20.4 | 14.6 |
| Denver, Colo. | 15.4 | 23.0 | 22.8 | 14.9 | 7.0 |
| Detroit, Mich. | 59.9 | 93.1 | 79.7 | 52.0 | 28.0 |
| Houston, Texas | 18.1 | 25.3 | 19.2 | 18.4 | 14.8 |
| Kansas City, Mo. | 24.5 | 38.7 | 38.0 | 26.5 | 10.8 |
| Memphis, Tenn. | 18.9 | 26.6 | 24.0 | 18.4 | 13.1 |
| Minneapolis-St. Paul, Minn. | 29.0 | 39.1 | 38.1 | 23.7 | 11.9 |
| New Orleans, La. | 34.4 | 46.6 | 42.9 | 34.5 | 28.0 |
| New York, N. Y. | 259.9 | 387.5 | 387.2 | 310.4 | 190.1 |
| Omaha, Neb. | 10.2 | 17.1 | 19.5 | 10.8 | 4.9 |
| Philadelphia, Pa. | 91.0 | 153.4 | 152.5 | 113.6 | 52.5 |
| Pittsburgh, Pa. | 49.8 | 76.7 | 78.4 | 56.1 | 29.0 |
| Portland, Ore. | 17.2 | 15.9 | 12.4 | 12.7 | 9.5 |
| St. Louis, Mo. | 44.0 | 95.9 | 99.9 | 59.6 | 27.9 |
| Seattle, Wash. | 19.0 | 20.3 | 13.1 | 16.8 | 11.2 |

Source of data: United States Department of Agriculture. Agricultural Marketing Service. Carlot unloads of certain fruits and vegetables in 66 cities and imports in 4 cities for Canada. Annual issues. Washington, D. C. (Processed)

TABLE 37

Summer Lemons: Regression Coefficients and Auxiliary Constants Obtained When Mean Maximum Temperature in 22 Cities is Used as the Temperature Variable
(Figures in parentheses are standard errors)

| Dependent variable | Net regression coefficients * | | | | | Adjusted coefficient of multiple correlation $\bar{R}$ | Flexibility of price $\varphi$† | Elasticity of demand $\eta$† | Percentage of variance of dependent variable ascribable to | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Constant term | F.o.b. price $x_1$ | United States supply $x_2$ | Nonagricultural income $x_3$ | Mean maximum temperatures $x_4^o$ | | | | $x_1$ | $x_2$ | $x_3$ | $x_4^o$ |
| $x_1$ | -26.1255 | | -0.0189<br>(0.0020) | 0.0490<br>(0.0071) | 0.4100<br>(0.0695) | 0.9031 | -1.8067 | | | 70.9 | 10.8 | 2.7 |
| $x_2$ | -1,381.9485 | -44.5889<br>(4.8363) | | 2.5302<br>(0.2732) | 21.3450<br>(2.7835) | 0.9482 | | -0.4658 | 38.9 | | 32.5 | 20.1 |

* $x_1$ = Seasonal average f.o.b. price in dollars per box.

$x_2$ = United States supply of lemons in units of 10,000 boxes.

$x_3$ = Index of nonagricultural income payments, 1935-39 = 100.

$x_4^o$ = Mean monthly maximum temperature in 22 cities, May through September.

† At the centroid.

### TABLE 38

Summer Lemons: Correlation Matrix and its Inverse Obtained

When Mean Maximum Temperature in 22 Cities is Used as the Temperature Variable

| | Correlation matrix | | | | Reciprocal matrix | | | |
|---|---|---|---|---|---|---|---|---|
| | $x_1$ | $x_2$ | $x_3$ | $x_4^o$ | $x_1$ | $x_2$ | $x_3$ | $x_4^o$ |
| $x_1$ | 1 | | | | 6.441653 | | | |
| $x_2$ | -0.572288 | 1 | | | 7.984304 | 11.759235 | | |
| $x_3$ | 0.118360 | 0.452897 | 1 | | -5.875439 | -8.437056 | 7.182498 | |
| $x_4^o$ | 0.036886 | 0.341278 | -0.312107 | 1 | -4.796239 | -6.940941 | 5.337810 | 5.211672 |

For the meaning of the x's, see table 37.